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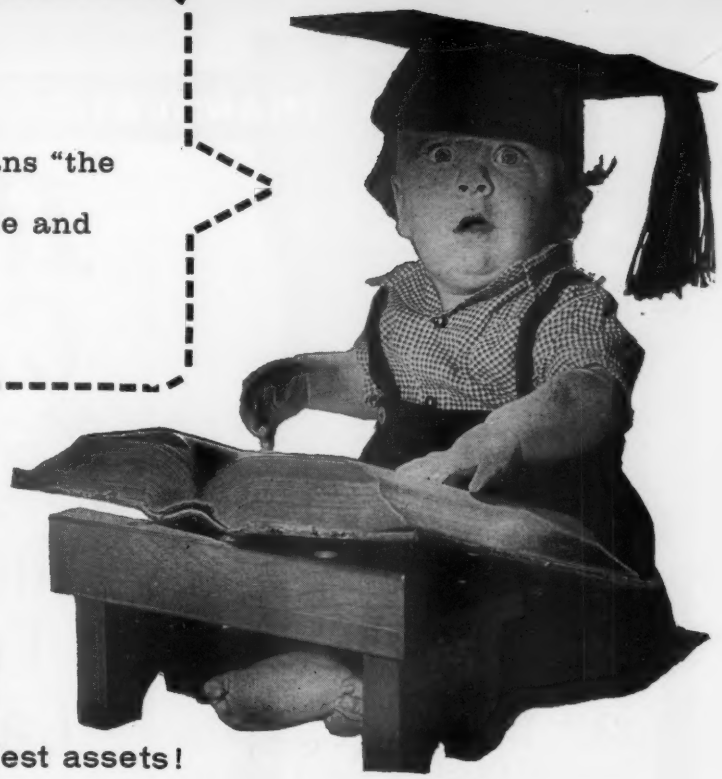

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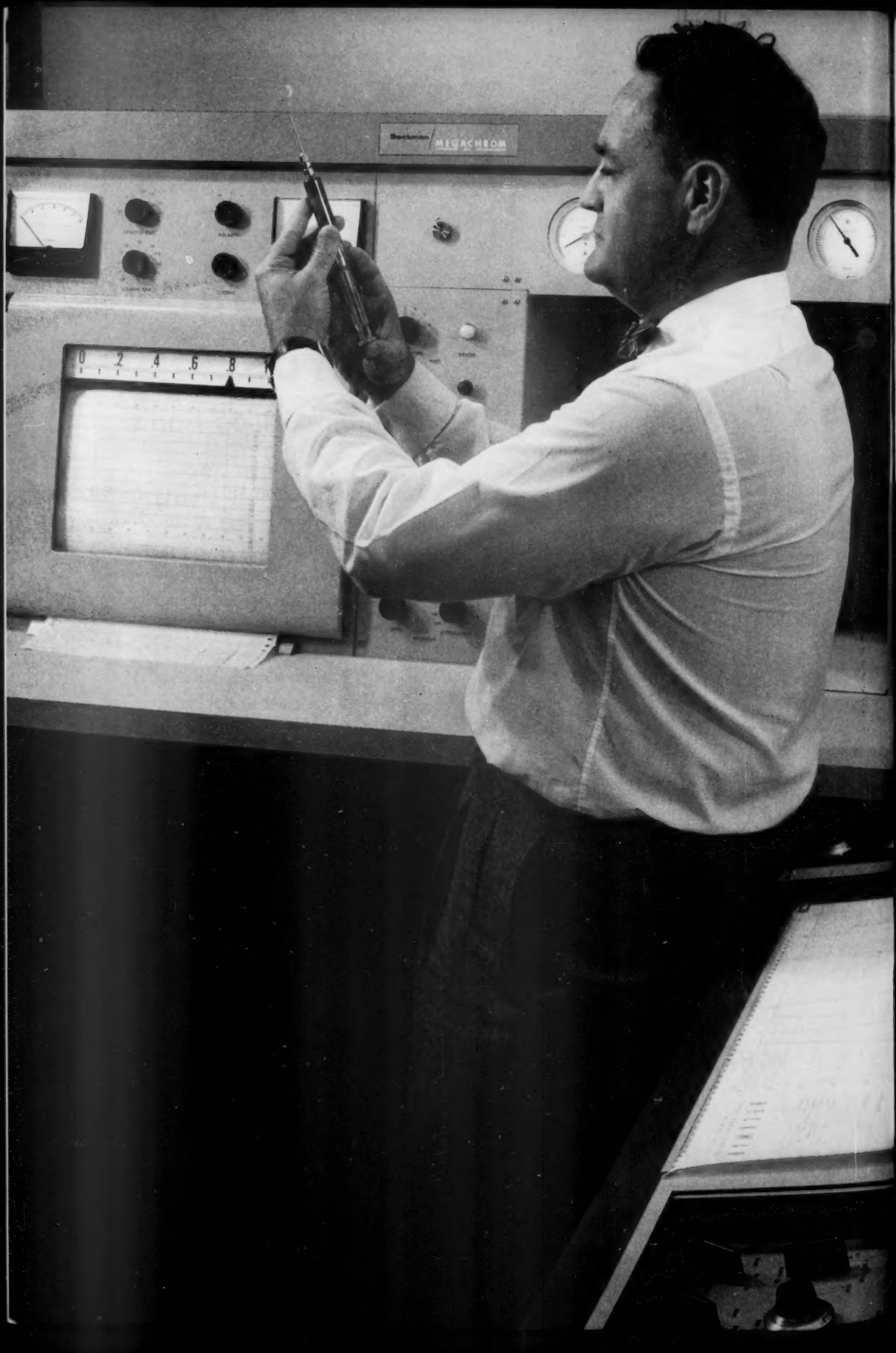
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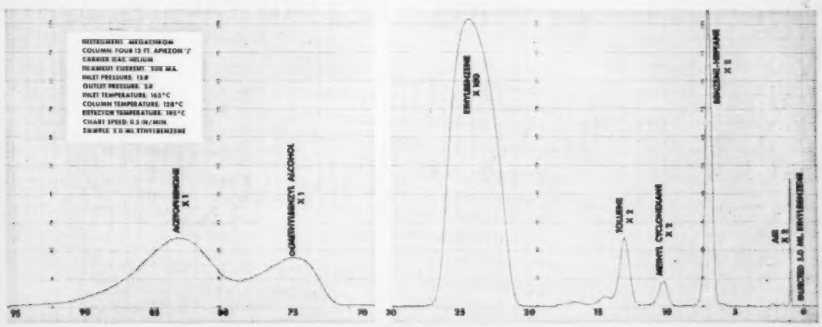

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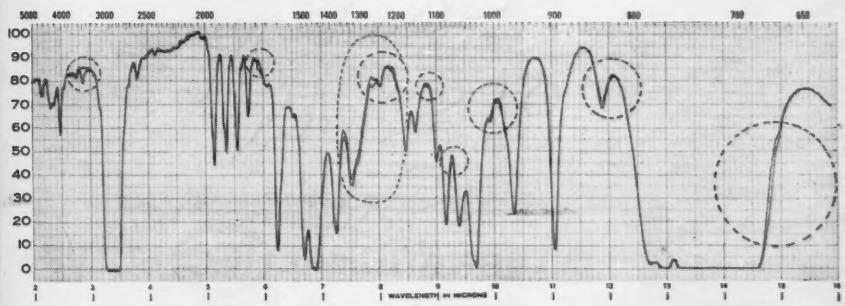

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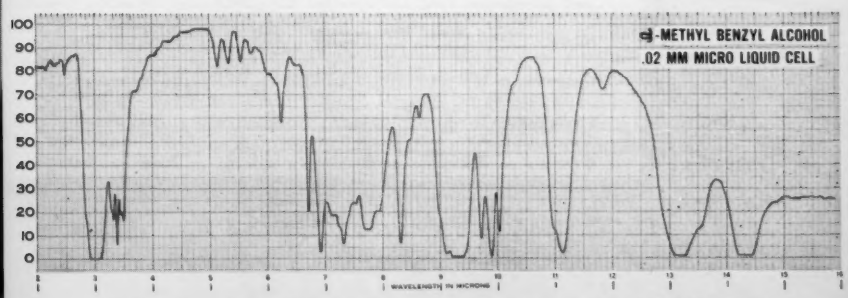

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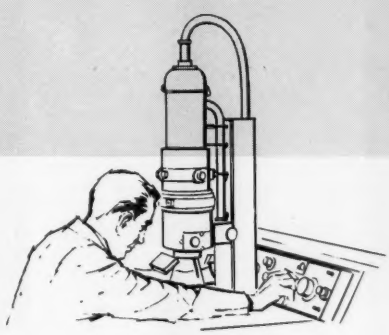

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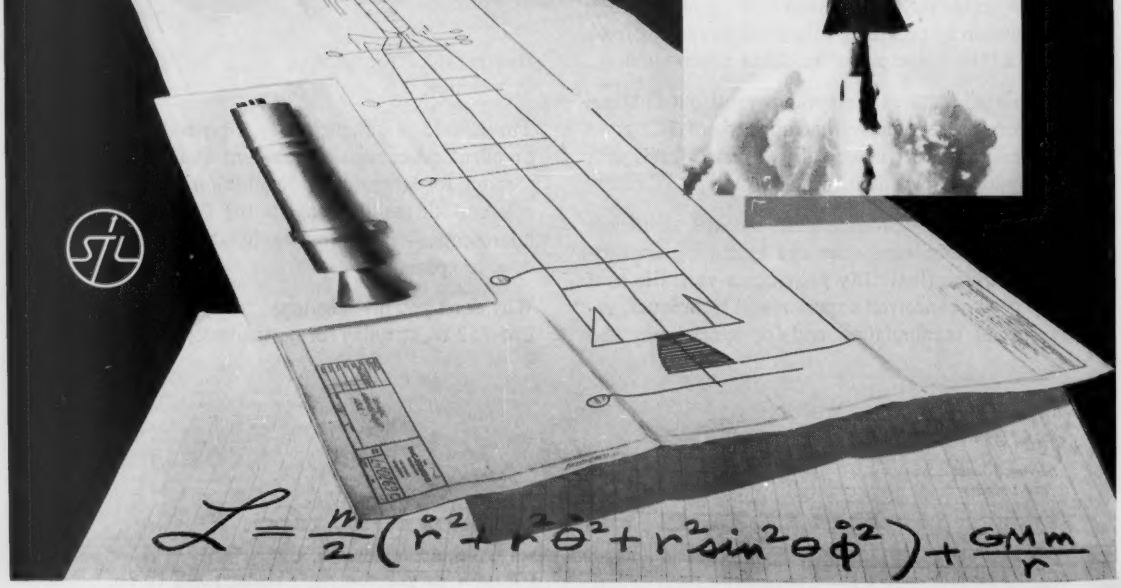

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Money Still Isn't Everything

Each year at this time Congress takes the bit in its teeth and raises by a substantial amount an Administration request for appropriations for scientific research. The funds are for the National Institutes of Health at Bethesda, Maryland, and this year the increase was from $294 million to $400 million—36 percent. More money for research should be given a hearty welcome, but some scientists regard this increase a bit wryly. Why so? Part of the answer is that it may not be possible to spend so much money so quickly without significantly lowering present research standards. President Eisenhower made this point when with some reluctance he signed the bill. But part of the answer also lies in the manner in which differences of opinion among scientists about the best way to conduct research are now resolved.

To give an example of a difference of opinion among scientists: although everyone agrees that it would be splendid if science found a cure for cancer, the problem is how should science proceed? Some investigators see great hope in testing one chemical compound after another for its effects on tumors and healthy tissue. There is a reasonable chance, these investigators believe, that a screening program will lead to the discovery of drugs that will significantly retard, cure, or prevent various kinds of cancer. Such a program requires an organized effort, a large budget, and a great number of scientists, all capable of identifying a significant effect when they see one.

Attempting to take the citadel by storm has been a respectable procedure since at least the time of Paul Ehrlich's 606 trys at finding a cure for syphilis. But other investigators hold that, although it is fine for some workers to screen compounds for possible effects on tumors, *they* have no wish to do so. In fact, these other investigators do not even set their sights on anything so specific as a cure for cancer. They are interested in seeking better understanding of how cells function. Of course, with increased understanding of how cells function may come increased understanding of what causes cancer and, consequently, of how to cure it.

The manner in which such differences of opinion are resolved explains why some scientists regard the yearly increase in appropriations with mixed emotions. The differences are resolved in good part by Congress, which has its own ideas about priorities in research. In making up the money bill, the legislators indicate in considerable detail just how the funds they appropriate should be spent. Many observers on one hand will laud the support Congress has given the chemotherapy program of the National Cancer Institute, but on the other hand will find that fundamental studies are being shortchanged. In arriving at its decisions, Congress has the benefit of testimony by many scientists, some of whom are of the first rank, but something goes wrong when Congress then proceeds to pinpoint research targets for the scientific community. Certain programs by their very nature are going to have greater appeal for the legislators and their constituents than other programs.

Congress seems right in saying, through its yearly appropriation increases, that an expanding program of medical research should be a part of national policy. But to achieve good results, an expanding program requires a long-range plan, a proper balance between various kinds of research, and not too many detailed directives. Much would be gained if the Administration took the initiative in preparing such a plan. Perhaps the President's Science Advisory Committee, with its good record of advice on questions of science in national defense and foreign policy, should turn its attention to the advancement of medical research.—J.T.

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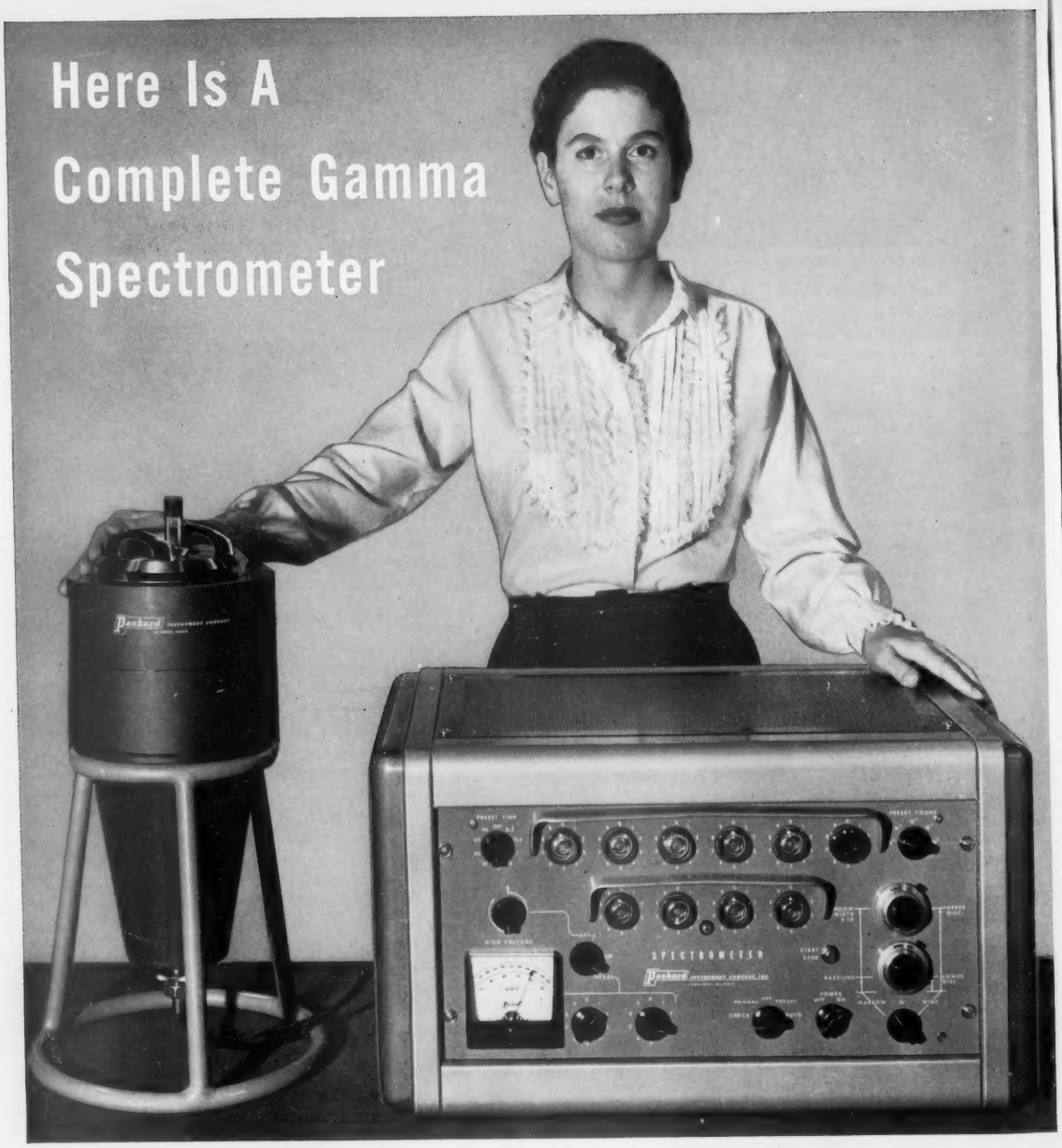

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SCIENCE

CURRENT PROBLEMS IN RESEARCH

Redistribution of Wealth through Inflation

Contrary to the generally accepted view, business firms do not necessarily gain through inflation.

Armen A. Alchian and Reuben A. Kessel

Economists have long speculated about the effects of inflation upon the economic welfare of the owners of business enterprises. This speculation has almost invariably led to the conclusion that business firms gain through inflation. This conclusion has been reached through two independent arguments. One, enunciated by both J. M. Keynes and I. Fisher, is that inflation enables business firms to discharge their debts with depreciated money, the creditors' losses being the debtors' gains (*1*). Strictly speaking, the validity of this conclusion depends upon two propositions: (i) that business firms are debtors, and (ii) that interest rates reflect biased estimates of the future course of prices when prices are rising. The other argument, advanced by E. J. Hamilton and W. C. Mitchell, is that inflation causes prices to rise faster than wage rates (*2*). Consequently workers are systematically underpaid during inflation, this loss by the working class being a gain for the entrepreneurs (*3*). This explanation rests upon special assumptions about the character of labor markets that are generally regarded as invalid in other markets.

Practical men of affairs, in particular investment advisers, have been much less confident than professional economists that the owners of business enterprises gain through inflation. They have generally concluded that investors can maintain their capital intact during inflation by investing in common stocks, such an investment being roughly equivalent to an investment in inventories. (Common stocks are ownership or equity shares in a corporation, while bonds represent debt obligations of the corporation.) In other words, an investor in common stock could expect neither to increase nor to decrease his wealth, whereas an investor in bonds and other cash-type investments would suffer a real loss.

This cautiousness of investment counselors is traceable to the experience of investors in equities during the great inflations that have occurred in countries with organized stock markets. It was found during the German runaway inflation following World War I, during the Austrian and French inflations of the 1920's, and more recently during the inflation in Chile that the owners of business firms did not obtain the gains that might have been expected on the basis of the hypotheses set forth by Keynes and Fisher, on the one hand, and Hamilton and Mitchell on the other. These observations are also consistent with the behavior of stock price indexes in the United States during the inflations associated with world wars I and II.

What was especially puzzling was the fate of the owners of banks. Banks are typically enormous debtors, larger debtors, in fact, than most business firms by an order of magnitude. Furthermore, banks employ relatively more labor per dollar of invested capital than is characteristic of business firms generally. Consequently, it is an implication of both hypotheses that banks ought to be enormous gainers through inflation. Yet the available evidence suggests that one of the regular results of inflation is that the owners of bank shares suffer. The experience of the owners of bank shares in the United States, Germany, Austria, Chile, and France suggests that the real value of bank shares declines during inflation. (Real value is simply price divided by an index number reflecting changes in the price level. Consequently, if the price of an asset rises more than the price level, then its real value has increased, and conversely.)

Reconciling Hypotheses with Experience

How can this evidence be reconciled with either of these hypotheses? A step toward reconciling the Keynes-Fisher reasoning with the lessons of experience as revealed by the stock market was taken by Kessel when he showed that, despite the enormous debts owed by banks to depositors, there exist offsetting credits that are even larger than these debts (*4*). These credits are bank assets which are almost entirely (with the exception of bank buildings and business machines) either money or money-type assets such as notes and other obligations payable to banks by either private customers or the government. The existence of these credits led Kessel to argue that one should do more than merely look at the credit that business firms have extended to their customers. What business firms gain from bondholders may be lost to those to whom these firms have extended credit and may never redound to the interests of the owners.

From his analysis emerged a classification for determining whether or not a business firm is, on *net* balance, a debtor

Dr. Alchian is professor of economics at the University of California, Los Angeles. Dr. Kessel is assistant professor of economics at the University of Chicago, Chicago, Ill.

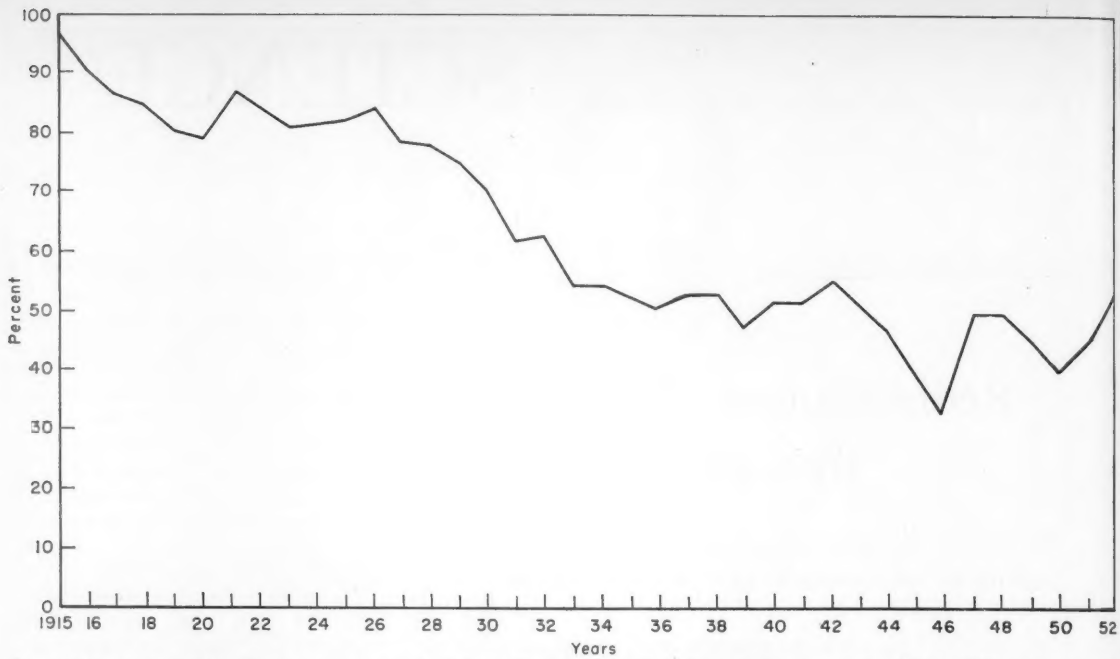

Fig. 1. Net monetary debtor firms as percentage of all firms. [Based on New York Stock Exchange data for 1915 to 1952 and on American Stock Exchange and "over-the-counter" data for 1940 to 1952]

or creditor. Kessel classified assets and liabilities into categories, monetary and real. A monetary asset was defined as an asset whose market value is independent of changes in the price level. These would include money, accounts and notes receivable, government and corporate bonds, life insurance, prepaid taxes, and so on. A monetary liability was defined as a liability whose amount is independent of changes in the price level; these would include accounts payable, notes payable, mortgages, bonds, preferred stock, and so on. Preferred stock, although called a stock, is typically corporate debt rather than equity. A net monetary debtor was then defined as a firm whose monetary liabilities exceeded its monetary assets; and conversely for a net monetary creditor. The net monetary status would indicate the magnitude of the gain or loss a firm would incur from a given amount of inflation. However, firms with the same amount of indebtedness but of unequal size, where size is measured by the aggregate value of the equity of the owners, would have unequal movements in absolute stock prices. Therefore, in order to compare corporations of unequal size, the ratio of net monetary debt to equity, as measured by the market price of shares times the number of shares outstanding, is used as the measure of net monetary debtor or creditor status (*5*). The effects of stock dividends, stock splits, and rights offerings were held constant and did not affect measurements of changes in stock prices. "Stock dividends" and "splits" increase the number of shares of common stock without changing the total investment, whereas "rights" entitle existing stockholders to increase the investment in the corporation by purchasing new shares at a price below existing market prices, thereby also involving some dilution in per-share value. And it was assumed that dividends were continuously reinvested in the shares of the companies that issued them, because this would eliminate variations caused by differences in the extent to which profits were reinvested.

For the United States, Kessel found in his preliminary study that banks were typically net monetary creditors, and that the real value of their shares actually did decline during the World War II inflation, in accordance with the Keynes-Fisher hypothesis. Furthermore, the real value of bank shares seems to have gone down during inflation for every country for which data are available.

Kessel also examined the balance sheets of a small random sample of industrial firms whose stock is traded on the New York Stock Exchange. (Railroads, utilities, and investment companies were omitted. Railroads and utilities were not included because it was supposed that their very close regulation might conceal the effects of inflation upon their stock prices. Investment companies were omitted because of the magnitude of the problems encountered in evaluating the debtor-creditor status of their assets.) In 1939, about 40 percent of the observed firms were creditors and could be expected to lose through inflation, according to the Keynes-Fisher reasoning. After the firms had been divided into the two categories, debtor and creditor, and after the changes in share prices between 1939 and 1946 had been examined, a significant difference was detected between the rise of share prices in the two categories. The share prices of net monetary debtor firms rose significantly more than the prices of net monetary creditor firms. For a period of deflation, 1929–1933, the reverse was found to be true. The share prices of net monetary creditors fell significantly less than the share prices of net monetary debtors.

The behavior of the stock prices of bank shares during the inflation associated with World War II was indistinguishable from the behavior of the shares of equivalent industrial creditors. Other evidence indicates that banks were characterized by large amounts of labor per dollar of invested capital as compared with enterprises generally. This evidence casts doubt upon the validity of the Hamilton-Mitchell reasoning, that infla-

tion causes real wages to fall. If the wage lag had been operative, the value of bank shares would have risen more than the value of the shares of equivalent industrial creditors.

This evidence validated the proposition that during inflation interest rates are systematically lower than they ought to be if inflation is not to transfer wealth from creditors to debtors, but it also challenged the assumption that business firms are, in large part, debtors. The mechanism for redistribution that Keynes and Fisher envisaged was correct, but their assumption that business firms were generally debtors was wrong, and it was this that led them to the erroneous conclusion that business firms gain through inflation. This evidence also explains the behavior of stock-price indexes during inflation. If a substantial fraction of all business firms were net monetary creditors, then an index number of stock prices that was composed of both net monetary debtors and net monetary creditors would not necessarily rise in real value during inflation. Indeed, if the debtors just balance out the creditors, one would expect stock prices generally to keep pace pretty closely with the general price level. These results led to a much larger-scale investigation, designed both to provide stronger evidence of the validity of the mechanism for redistribution envisaged by Keynes and Fisher and to enlarge our empirical knowledge of stock prices (*6*).

New Evidence for Mechanism of Redistribution

The population of firms investigated includes all of the industrials whose common stock was traded on the New York Stock Exchange at any time between 1914 and 1952. For 1933–1952, the American Stock Exchange was also included. Furthermore, four separate industries were studied for the period 1940–1952—chemicals, steels, retailing, and textiles—in order to hold constant any industry differences. The period of the study, 1915–1952, includes two inflations (world wars I and II), two deflations (1921–22 and 1928–1933), and two periods of relative price stability (1923–1930 and 1933–1940). The number of firms observed in a year ranged from a minimum of 71 to a maximum of 885. In all, nearly 14,000 firm-years of data were observed and analyzed.

What do these data show? The distribution of firms by net monetary debtor and net monetary creditor status has changed spectacularly since 1914. The percentage of firms in each category is shown in Fig. 1. These data are based on the New York and the American Stock Exchange samples. The shift from predominantly net monetary debtor status, around the time of World War I, to a ratio of approximately 50:50 in 1952 may explain why Keynes and Fisher made the assumption they did about business firms being debtors.

Apparently individual firms usually did not shift their net monetary status frequently. A firm that was a net monetary debtor in one year was very likely to be one in the next year, despite a gradual shift of the population as a whole. A classification of firms during

Table 1. Observed stock price values (with reinvested dividends) for episodes of inflations, deflations, and stable prices, by exchanges and industries. [From *Moody's Industrials* (1914–1953); *Commercial and Financial Chronicles* (1921–1953); *Bank and Quotation Journals* (1928–1953); and New York *Times* (1915–1953)]

Population sampled	Kind and No. of firms*		Mean resulting equity value† ($)	Mean of debtor minus creditor‡ ($)	t§	p‖
		Inflations				
1915–1920:						
New York Stock Exchange	Debtors	78	2.66	+1.06	3.27	.001
New York Stock Exchange	Creditors	22	1.60			
1940–1952:						
New York Stock Exchange	Debtors	29	5.93	+1.47	1.80	.05
New York Stock Exchange	Creditors	35	4.46			
American Stock Exchange	Debtors	57	11.30	+3.25	1.65	.05
American Stock Exchange	Creditors	70	8.05			
Over-the-counter	Debtors	22	9.38	+2.93	1.19	.12
Over-the-counter	Creditors	45	6.45			
Steel industry	Debtors	29	6.92	+0.25	.15	.44
Steel industry	Creditors	27	6.67			
Chemical industry	Debtors	19	7.17	+2.53	1.24	.12
Chemical industry	Creditors	19	4.54			
Textile industry	Debtors	29	16.33	+6.67	1.45	.07
Textile industry	Creditors	22	9.66			
Department stores	Debtors	29	8.96	+4.81	2.64	.007
Department stores	Creditors	22	4.15			
New York Stock Exchange wage firms	Debtors	50	7.85	+2.07	1.76	.04
New York Stock Exchange wage firms	Creditors	32	5.78			
		Deflations				
1921–1922:						
New York Stock Exchange	Debtors	118	1.48	−0.30	−1.73	.045
New York Stock Exchange	Creditors	24	1.78			
1928–1933:						
New York Stock Exchange	Debtors	63	.49	−0.60	−3.17	.001
New York Stock Exchange	Creditors	35	1.09			
		Stable prices				
1923–1930:						
New York Stock Exchange	Debtors	50	2.78	+0.45	1.08	.14
New York Stock Exchange	Creditors	15	2.33			
1933–1940:						
New York Stock Exchange	Debtors	56	4.31	−0.80	− .89	.81
New York Stock Exchange	Creditors	54	5.11			
American Stock Exchange (curb)	Debtors	17	6.44	+1.72	+ .71	.52
American Stock Exchange (curb)	Creditors	20	4.72			

* Number of firms that maintained debtor (or creditor) monetary status during at least ⅔ of the episode.
† Mean price plus reinvested dividends at the end of the episode, per dollar of 1940 stock prices.
‡ Mean equity value for net monetary debtors minus mean value for net monetray creditors.
§ Student's t test coefficient:

$$t = d \Big/ \left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}\right)^{1/2}$$

‖ Sampling probability of t (one-tailed) based on Welch approximation. [B. L. Welch, "The generalization of student's problem when several different population variances are involved," *Biometrika* 34, 28 (1947). Two-tailed test is used for periods of price stability]

the 1915–1920 inflation according to net monetary status shows that 78 of the firms were net monetary creditors during at least 4 years of the 6-year span, while 22 were net montary debtors during at least 4 of the 6 years. A few did not retain their status for as long as 4 years. According to Keynes and Fisher the net monetary debtors should have had an increase in the values of their stocks relative to the net monetary creditors. The observed data show that $1 of equity of the net monetary debtors increased to $2.66, while the net monetary creditors' dollar increased to only

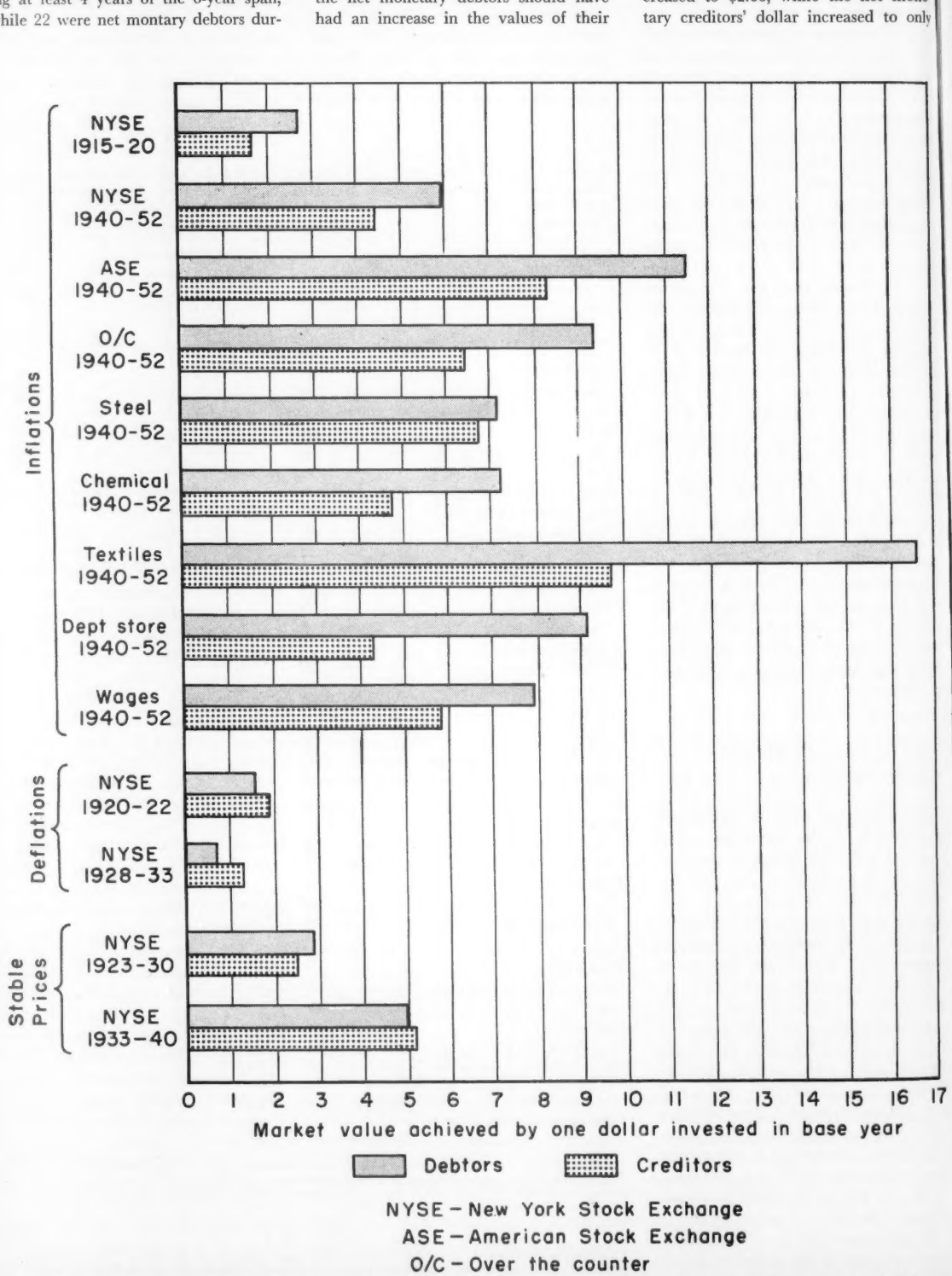

Fig. 2. Market value of equity for debtors as compared to that for creditors (per dollar of base-year common stock value).

$1.60; the superiority is 57 percent and one which would have less than 1 chance in 1000 of occurring by an unusually favorable random selection of firms if there really were no transfers of wealth from creditors to debtors.

Table 1 contains more details, as well as the results for the inflation of 1940–1952, for each of the populations of firms studied. In every instance the net monetary debtors did better. In Fig. 2 these results are given in the form of a graph. The probability sampling levels are sufficiently small to make it extraordinarily difficult to attribute such results to random sampling. And when the probability levels are combined by the R. Fisher chi-square method, the sampling probability falls to below 1 chance in 10,000.

To test whether the results are attributable to inflation rather than to a hidden factor which makes the better firms become net monetary debtors, the deflationary episodes were also considered. In the two deflations of 1921–22 and 1928–1933, the firms were again classified according to whether they were persistently net monetary debtors or creditors. In the short deflation of 1921–22, each firm in the sample maintained its monetary status during the entire period. In the 1928–1933 episode, one deviation was permitted. In both deflations the net monetary creditors did better than the net monetary debtors—just the opposite of the finding for inflations and in conformance with the predictions of the Keynes-Fisher model. The sampling probability levels are small, being less than 5 percent for the short deflation of 1920–22 and less than 0.1 percent for 1929–1932. The combined sampling probability is less than 0.01. Finally, for the periods of price stability of 1923–1930 and 1933–1940, a similar classification of firms revealed no difference in performance between the net monetary creditors and the net monetary debtors, again in conformance with the Keynes-Fisher hypothesis as modified here. These results are also given in Table 1.

But what about the Mitchell-Hamilton wage-lag hypothesis and its implications for business profits? Possibly labor intensiveness is correlated with net monetary status. Under these circumstances, the wage lag, while unrevealed, might yet be operative. To explore this possibility as well as the possibility that growth might be correlated with debtor-creditor status, a sample of 113 firms listed on the New York Stock Exchange was obtained. These firms were the entire population of industrials that reported wage bills some time during the interval 1940 to 1952. Three variables—(i) net monetary debtor or creditor status per dollar of equity, (ii) wages paid per year per dollar of equity, and (iii) yearly sales per dollar of equity—were evaluated for potential predictive content by means of partial correlation analysis. (Equity values were determined by the market price of shares.) And in order to avoid violating assumptions underlying probability tests of significance for correlation analysis, ranks for the three independent variables were used.

The results of this analysis revealed that *only* net monetary status was correlated with relative stock price changes, and that this correlation was in the predicted direction. Moreover, the chance that this observation would be produced by random sampling from a population characterized by an absence of this correlation is less than 1 in 1000. This evidence is completely consistent with the hypothesis that the wage lag is inoperative—that is, that the imperfection of the labor market postulated by the wage-lag theorists is nonexistent. Consequently, these results must be regarded as evidence against the hypothesis that a wage lag increases business profits during inflation. However, one must not lose sight of the fact that this is only partial evidence, from a nonrandom sample consisting of 113 firms.

Conclusion

These results, reported here for the first time, while constituting overwhelming evidence in support of the Keynes-Fisher reasoning about the bias in interest rates during inflation, fail to support their conclusion that business firms gain through inflation. The frequency of debtors in the business population is not great enough to justify Keynes and Fisher's sweeping statements about the gains of business enterprise through inflation. This evidence also suggests that the Keynes-Fisher theorizing about the effects of inflation is not specific to business enterprises; it is a general theory of wealth transfers caused by inflation and is equally applicable to individuals. What count are monetary asset and monetary liability positions and not the type of economic activity in which one engages.

Especially pertinent to much of the current discussion of the consequences of inflation is that the present evidence, by validating the wealth-transfer effect from monetary creditors to monetary debtors (and rejecting the wage-lag hypothesis), verifies the implication that inflation is basically a "tax" on creditors in favor of debtors. Inflation constitutes a tax on the wealth of individuals to the extent that they are holders of money-type assets rather than savers, wage-earners, businessmen, widows, orphans, or retired schoolteachers.

These results have implications for the adjustment of personal investment and wealth portfolios (including not only stocks, but bonds, life insurance, mortgages, charge accounts, cash holdings, and so on) in order to hedge against inflation or to profit if inflation comes. Similar reasoning applies to the management of investment, pension, and trust funds.

References and Notes

1. J. M. Keynes, *Tract on Monetary Reform* (London, 1923), p. 18; I. Fisher, *The Purchasing Power of Money* (New York, 1920), pp. 58–73, 190–191.
2. E. J. Hamilton, *J. Econ. Hist.* 12, 325 (1952); W. C. Mitchell, *A History of the Greenbacks* (Chicago, 1903), pp. 347–348; ———, *Gold, Prices, and Wages under the Greenback Standard* (Berkeley, 1908), pp. 275–276.
3. Some economists and noneconomists also contend that anyone who holds inventories gains through inflation. Since the price of inventories rises above their cost, this difference is regarded as a real gain in economic welfare. But holders of inventories cannot acquire with their inventories any more of the world's goods and services than they could in the absence of inflation.
4. R. A. Kessel, *Am. Econ. Rev.* 46, 130 (1956).
5. This is one of the respects in which the present study is an advance over Kessel's early work. While his concept of net debtor or net creditor was correct, his criterion of *intensity* of debtor or creditor status was wrong, and consequently the measurements based upon his criterion were also wrong.

6. This study was undertaken with the aid of a research grant from the Merrill Foundation for the Advancement of Financial Knowledge. The article, from this point on, constitutes the first statement of some of the results of this study.

Freedom in Research

Like food, we should have it in sufficient measure, but we should not need to assure ourselves by gluttony.

J. R. Pierce

In these days, freedom is mentioned so often in connection with research that a naive person might come to believe that freedom is, if not an end in itself, at least a sovereign ingredient which ensures success.

Whatever freedom may be, we sometimes feel that we want it above all things; we long for freedom, not only from the tyranny of people and events but from the weaknesses of flesh and spirit, from our appetites and our aspirations alike. This freedom, which I believe we shall eventually have in full measure, is very different from freedom as it appears to a willful child—having his own way from moment to moment, regardless of consequences to himself or others.

If there are indeed many sorts of freedom, then many sorts of freedom may be important in research. However, we will merely become confused by trying to identify freedom with the course and aim of research. The course of research is intelligent, creative, and enthusiastic work toward an end. The aim of research is new understanding or new accomplishment. Freedom will be important to research insofar as it contributes to the wise choice of problems and to the enthusiastic and successful pursuit of solutions.

It seems clear that the research worker must be free to work on a problem which challenges and interests him and which is yet within his capabilities, rather than a problem which he finds dull or which is beyond his abilities. He must be free to equip himself adequately to tackle his problem, with physical apparatus, of course, and also intellectually, through study or through contact with others, near or far. Without a good measure of such freedom, successful research just can't be carried out.

However, freedom should be like the food we eat. We should have a sufficient measure of freedom at hand when we need it. It should not be necessary for us to reassure ourselves about our freedom by engaging in ostentatious discussions or acts of freedom any more than it is for us to assure ourselves of continued sustenance by ostentatious gluttony. Indeed, a mania for freedom may be just as destructive to research as a lack of it.

We all know people who come around with a wonderful new idea every month, week, or day (maybe it just seems like once a day). I don't believe that even a great genius has that many ideas worthy of his serious effort. The man with an idea a day is unlikely to do anything substantial about any idea. He may become disgruntled because he cannot force others to work on his ideas, or he may unhappily work on one idea and bemoan the tyranny of the world in general. In no case is he apt either to make himself happy or to enrich the world.

Freedom does not even require that a man work on his own ideas. To do so is fine if the ideas are the best ones at hand. But, above all, a man needs to work on good, well-chosen ideas. Eminent and creative mathematicians have worked on Hilbert's problems of their own free will ever since Hilbert propounded them. First-rate scientists have traveled halfway around the world to work under a particular person or with a particular group and have worked gladly on problems suggested by the person or pursued by the group. Many a first-rate man has thanked his lucky stars that someone suggested that he do this or that. The idea may come from a colleague near or far, or from a "boss" who is older, wiser, or cleverer than the man himself.

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Still, one does need freedom in choosing problems. It is deadly when a man feels that a problem is forced upon him, and even more deadly when he feels that it is a bad problem, either because the problem is just no good or because the problem is beneath or beyond his capabilities.

A man certainly doesn't need to exercise his freedom every day just to prove that it is still there, but it is a terrible thing to lose freedom, especially if it is lost little by little, so that he does not miss it until it is too late, or, even worse, does not realize that it is gone.

What, then, are the enemies of freedom? What can make a research worker unfree? I believe that several rather different things can do this.

Demands of Responsibility

It seems to me that freedom is an empty word unless it implies *real* alternatives among which there is some uncertainty about what one's choice will be. If this is so, responsibility is certainly one of the greatest enemies of freedom. The trouble is, however, that responsibility has its good features, too, so that everyone must arrive at some compromise between responsibility and freedom.

Most of us would find it easier to spend six months here and a year there or to change jobs entirely if it weren't for our wives and children. Some men solve this problem by not marrying. Some leave their wives and children to shift for themselves, and thereby gain in freedom.

Brain children, too, fetter some of us. The idea-a-day man is apt to be irresponsible concerning his ideas. He hopes, of course, that someone else will nurture them from bare existence into viability in a world of ruthless competition. Indeed, the chronic begetter of ideas may become angry when no one else gives his offspring the attention he is unwilling to lavish on them.

More responsible researchers pick a promising idea and spend endless time and effort helping it to find its place in the world. Some, indeed, unwisely go so far as to want to monopolize the idea after it has become self-supporting and has found its way into the lives of others.

Whenever we assume responsibility for an idea or a project, whenever we espouse it as our own, whenever we hold ourselves responsible for its fate, we have

lost a part of our freedom. However, such a loss is necessary if we are to accomplish anything.

Some people get themselves saddled with other sorts of responsibility. They have to decide or help decide who should be hired, who should be fired, how big a raise a man should get. They have to worry and fight about budgets, space, and rules and regulations. All this isn't so bad, but what really takes their time is the work of others.

I may be wrong, but I think that, by and large, research workers, even good ones, suffer more frequently from lack of help than from lack of freedom. It isn't merely that they need help in coping with nontechnical problems. They need help in choosing problems wisely, help in overcoming difficulties in their work, help in judging whether what they are doing is good or bad, help in getting rid of old projects which are really done, and help in getting into new things which will really be important and attractive. They also need not only encouragement for themselves but help in seeing that their work receives the recognition which it deserves. Only very rarely is a man completely self-sufficient. I know that I have benefited from and appreciated tremendously the ideas and help I have got from others.

Responsibility, both responsibility with respect to our own life and ideas and responsibility with respect to the ideas and lives of others, is sure to cost us a great deal of our freedom. However, we just can't get on without responsibility, and we must put up with the loss. We should, however, particularly realize that the more responsibility we assume for ourselves, the less anyone else has to or will assume for us.

Another thing that we can't do without is apparatus. Some ideas, some projects call for lots of expensive equipment. If a man has acquired a large-scale accelerator, a big radio telescope, or a large-scale computer, or if he has set to work on a large-scale experimental system of some sort, he is not likely to walk out on it because an attractive idea in some other field occurs to him. If a systems experiment is shackling him, he can abandon it if it is bad or complete it if it is good, but if he has an accelerator, a radio telescope, or a computer around his neck, he may be stuck in a field for life. This isn't fatal, of course; he can direct his thoughts to the field in question and have and pursue ideas in that field only. But he has lost freedom in that there is little chance that he will actually do something else, however much he may daydream about it. If he wants to recover his freedom, he can perhaps find a substitute, put him in charge, and leave him holding the bag.

Specialization Has Its Drawbacks

Another way we can lose freedom is through excessive and unwise specialization, which can eventually leave us no alternatives to choose among. At any moment any man should be better able to cope with the problems he is currently working on than with others. However, the problems in a field can be made to last forever, but the real need for and value of research in a narrow field may dry up and vanish. Or, a man may be a fine pioneer in a field but may not be suited to do the refined and mathematically difficult work which becomes necessary as time passes. Wisdom and good sense may dictate that he stop what he is doing and turn to something else. But he is scarcely free if he has lost the ability to do so.

A man can lose the freedom to change his work by allowing himself to become intellectually incompetent to deal effectively with anything outside of his current narrow field of specialization, or he can lose this freedom of choice by becoming so emotionally involved in his field that he cannot bear to leave it. He can also lose any real freedom of choice by convincing himself that he has some commercial and social stake in a field, a stake he cannot afford to lose; he can convince himself that he is valuable only because of his expert knowledge, or is looked up to only because of it.

Still, just as we must have responsibility and apparatus, so too we must have some degree of specialization, even if this does cut into our freedom. There is one curtailer of freedom, however, with which I think we could well dispense. That is snobbishness.

A college president once described to me a sort of pecking order of the sciences. According to him, the mathematicians look down on the physicists, the physicists on the chemists, the chemists on the biologists, and the biologists on the psychologists.

One sure and utterly frivolous and destructive way for a man to lose his freedom is for him to feel overwhelmingly impelled to choose his work, not on the basis of its suitability to his talents, not on the basis of its interest to him, not on the basis of its urgency or importance, but rather on the basis of its status in the eyes of some person, group, society, journal, or what not.

Finally, what might be called management (though it includes institutional policies of long standing as well as people) can affect the researcher's freedom.

On Changing Jobs

Sometimes a research worker may not have adequate funds for travel or for telephone calls, or he may find it difficult to get adequate apparatus or to get it promptly. These matters are frequently mentioned in connection with government laboratories. It is clear, however, that in these days of competition for engineers and scientists, a good man doesn't have to put up with such handicaps. He can go elsewhere to escape them, and he will.

Sometimes a man may feel that the scope of research in the institution where he works does not coincide with or include his interests. While an exceptional man may drastically alter the place at which he works (and this is desirable from time to time), a good man generally goes to a particular place because he is interested in the field and impressed by the quality of work done there.

A single man, even a very competent one, is bound to have much more freedom in changing his job than he is in changing what his associates are doing. This doesn't mean that he shouldn't try the latter, but a broad change in the nature or direction of the work of an institution involves other people's freedom as well as his own.

Finally, there can be a very real personal threat to a man's freedom; the tyranny of a boss. For research, it is absolutely essential that a man work on problems that he believes to be good problems for him and that he tackle them in a way in which he has confidence. We have noted that a man doesn't necessarily have to invent the problem or the general approach toward its solution himself.

Further, it is essential that if he does have a good idea, he should feel free to explore it (we have seen that he will not necessarily do so). He must further be convinced that his colleagues, including colleagues who may be bosses, welcome new ideas and are anxious to see them pursued and exploited. A free—indeed,

a cutthroat—competition among ideas is essential to research. It seems to me that a researcher should have no freedom to make other able people work on his ideas rather than on their own, beyond what he can make them want to do through persuasion based on the merits of his ideas.

Fortunately, today good people don't have to work under any other conditions. There is tremendous competition for good workers with good ideas. A man who really suffers from the tyranny of the boss can go to some other department or to some other company. And, if a boss is so tyrannous that good men leave him, he won't last forever.

Still, men do complain about the tyranny of jobs and bosses. It is my observation that these are seldom the best men. In fact, often they are men who have amply demonstrated their inability to do research when left completely to themselves, and sometimes they are men who should not try to do research under any circumstances.

Clearly, freedom is vitally important to research, but other somewhat inconsistent things are important, too. Responsibilities of one sort or another keep us from following up every idea or inclination we have. Apparatus ties us down. Concentration on one subject lessens our ability to tackle another. Then too, we may lose our freedom foolishly. Snobbishness may dictate our course of action. Or we may work in a poor environment, inadequately provided for, or with a tyrannous boss to browbeat us. But, in this day and age we are foolish if we put up with such things, unless we really aren't good enough to find another environment—or unless conditions aren't as bad as we think they are after all.

Stratospheric Carbon-14, Carbon Dioxide, and Tritium

The program of high-altitude balloon sampling reveals new information about the stratosphere.

French Hagemann, James Gray, Jr.,
Lester Machta, Anthony Turkevich

This article reports the results of measurements made in recent years of the carbon-14, carbon dioxide, and tritium in the stratosphere. The purpose of the measurements was to obtain information on the stratospheric concentrations of carbon-14 and tritium produced by the explosion of nuclear devices and to study the changes in these concentrations with time. Such data can be expected to furnish new insight into the circulation of the stratosphere, as well as to contribute to the evaluation of the hazards from nuclear explosions in the atmosphere.

The sampling program for carbon-14 was started in late 1953 at Minneapolis, Minn., and extended in 1955 to three other locations in the Western Hemisphere: San Angelo, Tex.; Canal Zone, Panama; and São Paulo, Brazil. The Minneapolis collection was shifted in June 1958 to Sioux City, Iowa. Carbon-14 was determined by measuring the specific activity of the carbon dioxide from air collected at altitudes between 45,000 and about 100,000 feet. Air samples were collected on a monthly schedule at four altitudes at each location unless operational difficulties prevented collection. The tritium measurements were performed only on samples collected at Minneapolis, primarily in the period 1957–58.

This article presents all of the significant original data and discusses the experimental errors which lead to correction of some of the values and rejection of others. Many of the technical details are omitted (*1*).

Sampling System

Basic equipment. A balloon-borne system was developed by General Mills (*2*) to collect samples of whole air from the stratosphere. The collection system (Figs. 1 and 2) consisted of four major components: a lift balloon, a collection bag, an armored vessel, and a control unit.

The lift balloon was a nonextensible plastic film (2-mil polyethylene) balloon of the "Skyhook" type. When the lift balloon reached its full size, excess helium was vented through a duct system so that the balloon would float at a predetermined altitude during the collection period. After collection of the sample, an electrically operated trap-door-type valve in the duct released the exact amount of lift gas necessary to insure a controlled, safe descent of the system. A parachute was suspended directly beneath the balloon to help smooth the rate of descent and to prevent free fall of the equipment in case of failure of the balloon.

The collection bag was a large balloon fabricated of the same material as the lift balloon. Two sizes of bags were used, depending on the collection altitude: a bag 47.5 feet in diameter was used at altitudes above 80,000 feet, and a bag 34.6 feet in diameter was used at lower altitudes. A collection blower of the centrifugal type, powered by a 24-volt direct-current motor, was located below the collection bag.

When measurements were to be made of tritium, a measured amount of deuterium tracer, in the form of heavy water, was introduced into the collection bag at the time of sampling. To accomplish this, a dispenser containing the tracer was located between the blower and the collection bag. The dispenser was kept at a constant temperature of 95°C. A fine orifice in the dispenser was opened during the time the blower was in operation so that the water vapor was introduced uniformly throughout the collection period. The amount of tracer introduced, 2 to 5

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grams, was determined by weighing the dispenser before and after collection of the sample.

The final airborne sample container was a 1400-cubic-foot armored vessel to which the air sample was transferred from the collection bag during descent. It was constructed in three layers to prevent loss of the sample upon impact with the ground. The inner liner, of gas-tight 4-mil polyethylene, was covered with a nylon fabric for protection against the heavy, coarse canvas "armor" of the outer bag. An axial flow blower was used to transfer the air from the collection bag to the armored vessel.

The control unit consisted of a power supply, master control unit, and barograph, all housed in a large, insulated, red bag. An upward-viewing sequence camera suspended below the control unit provided a record of the expansion of the lift balloon and the deployment of the collection bag.

Collection procedure. The following sequence of events took place in a typical sample collection operation. The system was launched and rose to its floating altitude. The intake trap-door valves on the collection blower were opened, and the blower was turned on for the predetermined time required to fill the collection bag. After the collection blower was turned off, a trap-door valve was closed, sealing the sample in the collection bag. The collection time varied from about ½ to 1½ hours, resulting in a sample of about 2000 standard cubic feet of air. A spring-loaded valve on the balloon then opened, allowing helium to escape, and the system began its descent. At approximately 33,000 feet, about 500 standard cubic feet of the 2000 cubic feet of air collected were transferred from the bag to the armored vessel. A barometric control automatically shut off the transfer fan when the 3000-foot level was reached.

During these operations a recovery crew tracked the course of the flight visually and with the aid of signals generated by a small radio transmitter included in the balloon train. The recovery crew proceeded by truck to the impact site and transferred the air sample with a four-stage compressor from the armored vessel to high-pressure cylin-

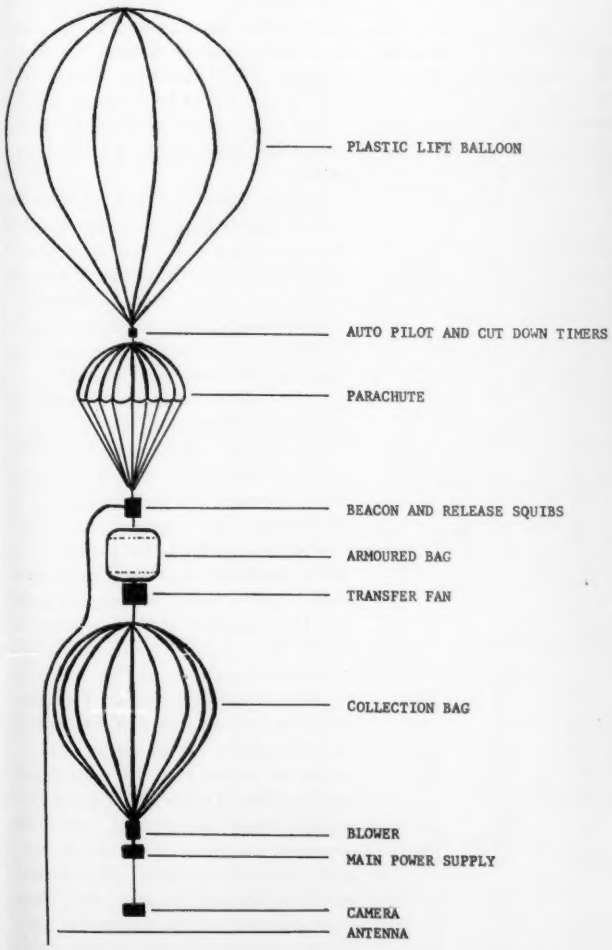

Fig. 1 (Left). Balloon train used in the collection of the stratospheric radiocarbon, carbon dioxide, and tritium samples. Fig. 2 (Right). Photograph of balloon train. See Fig. 1 for identification of visible parts of the train. The view shown is during descent, and the large collection bag has not yet transferred its air to the armored bag which hangs limply above it. The larger package at the bottom of the train is the filter apparatus which collects particulate stratospheric radioactivity. It is the size and shape of an ash can.

ders for shipment to the laboratory and subsequent processing and measurement.

Carbon dioxide was removed from some of the air samples, prior to their entering the compressor, with a trap refrigerated with liquid nitrogen. When a tritium analysis was to be made, a portion of the water vapor was frozen out of the air in a similar manner.

Carbon Dioxide

Advantage was taken of the availability of stratospheric air collected in this program to measure the concentration of carbon dioxide at high altitudes. A series of special small samples for this purpose were taken directly from the armored vessel to avoid possible alteration of the composition of the air in passage through the compressor and storage in the high-pressure cylinders. These samples were collected in small (1.7 liter) stainless-steel tanks, previously evacuated to a pressure of less than 10^{-3} mm-Hg in the laboratory. Aliquots of the air samples were taken near the start and end of the transfer from the armored vessel to the cylinders. Such samples were obtained at each of the four collection stations during the summer and fall of 1956.

The carbon dioxide concentration was determined by pumping a measured amount (500 to 1000 cm^3) of air, previously dried by passage through anhydrone, through a capillary trap cooled with liquid nitrogen. The separated carbon dioxide was distilled from a −80°C bath into a second trap cooled with liquid nitrogen, which was part of a capillary system of calibrated volume. The carbon dioxide was allowed to warm and expand, and the pressure was measured with a constant-volume capillary manometer. At least two replicates were run on each sample. The standard error of a single determination was estimated to be 0.5 percent, based upon observed recoveries from carbon dioxide-free air to which measured volumes of carbon dioxide had been added.

A similar series of direct air samples had been collected earlier at Minneapolis during the winter of 1954. In this case single aliquots were taken in glass flasks fitted with stopcocks. The method for determining carbon dioxide was similar to that described above, but with an estimated standard error of 1.0 percent.

The results of the measurements of the stratospheric concentrations of carbon dioxide are shown in Table 1. The table indicates no significant difference in the values obtained at Minneapolis in 1954 and in 1956. The agreement between the duplicate samples collected in 1956, with a few exceptions, is good. The samples collected at the start of transfer operations at Minneapolis on 1 August 1956 and at the Canal Zone on 1 August and 4 October 1956 gave values differing widely from samples collected at the end of the transfer and from the average. These values can be ignored as being nonrepresentative. The average value at Minneapolis for all altitudes studied is 312 ppm; at San Angelo, 310 ppm; at the Canal Zone, 312 ppm; and at São Paulo, 310 ppm. The average at about 50,000 feet for all locations is 311 ppm; at about 65,000 feet, 310 ppm; at about 80,000 feet, 313 ppm; and at about 90,000 feet, 310 ppm. The average concentration of carbon dioxide at all locations at altitudes of about 50,000 feet or greater is 311 ppm with an average deviation of less than 1 percent and a range of ±2 percent. This value is in close agreement with recent determinations of the concentration and variability of carbon dioxide in the troposphere (*3*).

Table 1. Stratospheric concentration of carbon dioxide.

Collection date	Altitude (10^3 ft)	CO_2 concentration (ppm)	
	Minneapolis, Minn.		
19 Oct. 1954	50	318	
4 Nov. 1954	50	316	
4 Dec. 1954	51	311	
27 Dec. 1954	61	308	
10 Jan. 1955	60	309	
23 Jan. 1955	60	308	
15 Oct. 1954	64	315	
27 Oct. 1954	66	312	
2 Nov. 1954	66	309	
19 Dec. 1954	65	310	
29 Dec. 1954	66	308	
27 Dec. 1954	71	308	
6 Jan. 1955	73	310	
20 Oct. 1954	79	317	
30 Nov. 1954	79	316	
6 Dec. 1954	79	311	
		Start	*End*
2 Oct. 1956	52	308	309
12 Sept. 1956	65	307	310
1 Aug. 1956	71–61	337	309
16 May 1956	83	309	310
13 Aug. 1956	80	311	323
30 Aug. 1956	90	319	315
	San Angelo, Tex.		
6 Aug. 1956	47	308	312
7 Aug. 1956	65	307	309
16 Oct. 1956	79	312	310
25 Aug. 1956	94	309	309
	Canal Zone		
7 Aug. 1956	54	319	314
1 Aug. 1956	67	258	314
21 Oct. 1956	87–83	312	318
4 Oct. 1956	97–90	346	304
	São Paulo, Brazil		
18 Aug. 1956	50	309	309
29 Aug. 1956	68–65	309	307
17 Aug. 1956	82–80	315	309
16 Aug. 1956	92–90	311	311

Carbon-14

Sample processing and measurement (*4*). The initial separation of carbon dioxide from the compressed air samples was accomplished by standard freeze-out techniques. In those cases in which freeze-out traps were used in the field, the traps were closed with valves and the separated carbon dioxide was shipped to the laboratory.

The separated carbon dioxide was purified for counting by the following procedure: (i) freezing and pumping at −196°C; (ii) reaction with CaO at 700° to 750°C to form $CaCO_3$; (iii) pumping the $CaCO_3$ to a high vacuum at 450°C; (iv) liberating the CO_2 by heating the $CaCO_3$ to 900°C; (v) freezing and pumping again at −196°C.

The radiocarbon was measured in proportional counters, the purified carbon dioxide being used as the counter fill. Considering the large number of samples to be measured, a sample size in the range of 1 to 2 liters of carbon dioxide was chosen as the best compromise between the convenience of sample preparation and the accuracy of the measurement.

The counters, 3 inches in diameter and 25 inches long, were constructed of stainless steel with a 1-mil stainless steel anode center wire; they had a sensitive volume of about 2.2 liters. When surrounded by a ring of anticoincidence Geiger counters and 12 inches of steel shielding, the counters, filled with 1 atm of inert carbon dioxide, had backgrounds of about 17 count/min.

As a routine procedure each gas sample was measured in at least two counters at pressures in the range of 30 to 76 cm-Hg. Each sample was usually counted for a period long enough to assure a statistical uncertainty of no more than 1 percent in the radiocarbon activity. The sensitivity of the counters was set at about 0.9 kev, using the monoenergetic x-rays from an Fe^{55} source as an internal energy standard. The number of undetected beta particles possessing less than 0.9 kev of energy was estimated to be less than 0.5 percent and was neglected. The end effect losses were experimentally determined, and the measurements were corrected appropriately. Although no direct experimental measurements were made, the wall losses were estimated to be no greater than about 1 percent, and the correction was neglected.

Results and errors. The results of the stratospheric carbon-14 measurements are listed in Table 2. The estimated

errors in the altitudes shown in column 2 are ±2500 feet for altitudes below about 70,000 feet and ±5000 feet for the higher altitudes. When the collection occurred over a larger range of altitude than 1000 feet, the actual range is shown. All samples were stratospheric except those marked with the letter T, which were definitely tropospheric, and those marked U, which could not be definitely assigned to the stratosphere. In column 3, the measured carbon-14 specific activities are given in units of disintegrations per minute per gram of carbon. The measurement errors of the unmarked values are estimated to be ±3 percent or less; of those marked with an asterisk, in the range ±3 to 5 percent; and of those marked with a dagger, in the range of ±5 to 10 percent. Values marked with the letter F were obtained from samples collected by a freeze-out trap in the field.

In a majority of samples the concentration of carbon dioxide was determined on aliquots of the compressed air, and the results are shown in column 4. Examination of these measured concentrations shows that about 60 percent of the values are between 295 and 327 ppm. About 17 percent of the values are higher than 389 ppm and only 0.5 percent are lower than 295 ppm. Comparison of the more than 50 cases where carbon-14 measurements were made for the same sample upon both field cold-trap-separated carbon dioxide and carbon dioxide separated from the compressed air showed that the specific activities of the field-trapped samples averaged about 10 percent higher than those of the compressed samples. These observations lead to the conclusion that inert carbon dioxide was introduced during the transfer of the air sample from the collection bag to the cylinder. In view of these considerations the measured specific activities were corrected somewhat arbitrarily as follows:

1) When both field trap and compressed air values were measured, the higher value of the specific activity, usually that of the trap sample, was chosen.

2) No correction was made when the measured concentration was between 295 and 327 ppm.

Table 2. Stratospheric concentration of carbon-14. In column 2, the letter *T* indicates that the sample was definitely collected in the troposphere. The letter *U* indicates uncertainty whether the sample was collected in the stratosphere or troposphere. Unmarked values indicate that the sample was collected in the stratosphere. In column 3, an asterisk indicates a measurement error of 3 to 5 percent, a dagger a measurement error of 5 to 10 percent. Unmarked values have measurement errors less than 3 percent. Values marked with the letter *F* indicate that carbon dioxide was separated in the field with a freeze-out trap. A carbon half-life of 5600 years and a concentration of carbon dioxide of 311 ppm were used to calculate the values given in column 5. After correction for variation in CO_2 concentration (see text) a natural background of 71×10^5 atoms per gram of air was subtracted to give excess carbon-14.

Collection date	Altitude (10^3 ft)	Observed specific activity (disintegration/min per g of carbon)	Measured CO_2 concentration (ppm)	Excess C^{14} (10^5 atom/g of air)
Minneapolis, Minn. (lat. 45° N)				
1953				
24 Sept.	81	16.8*		29
9 Oct.	82	17.8		36
5 Nov.	82	26.8†		89
12 Nov.	64	22.1*		61
17 Dec.	53	16.1†		25
23 Dec.	64	15.1*		19
1954				
28 Jan.	80	23.9*		72
28 Jan.	52	15.0*		18
28 Jan.	65	19.5*		46
6 Feb.	68–66	21.8		59
16 Feb.	79	30.8		113
22 Feb.	47	13.3*		9
22 June	98	27.6*		94
8 July	82	28.6		100
10 Sept.	49	16.1*		25
22 Sept.	79	36.8		149
15 Oct.	64	42.2		181
19 Oct.	50	14.3*		14
20 Oct.	79	27.3*		93
27 Oct.	66	46.9*		209
2 Nov.	66	52.0		240
8 Nov.	67	28.4		99
22 Nov.	95	36.1		145
22 Nov.	66	33.7		131
30 Nov.	79	104.6		554
4 Dec.	51	13.5*		10
6 Dec.	79	122.2		658
10 Dec.	65	34.1		133
19 Dec.	65	47.6		213
27 Dec.	61	31.8		128
27 Dec.	71	79.3*		402
29 Dec.	66	50.0		228
1955				
6 Jan.	49U	27.5*		94
6 Jan.	73	68.7		339
29 Jan.	66	30.8		113
30 Jan.	80	56.5		267
8 Feb.	71–68	66.4		326
8 Feb.	65	38.3		158
14 Feb.	59	29.0		102
1 Mar.	66	60.6		291
2 Mar.	49U	15.1*		19
9 Mar.	92	23.0		66
16 Mar.	77	67.8		333
16 Mar.	59U	20.8		53
28 Mar.	70	73.5		368
2 Apr.	60U	22.2		62
7 Apr.	50	23.5		70
25 Apr.	70	30.0†		108
25 Apr.	78	41.9		180
6 May	49–47U	13.2†		7
11 May	77	56.9		269
18 May	76	68.6		339
20 May	70	61.4		295
14 June	61–58	26.7		88
15 June	76	62.8		304
23 June	71	61.2		294
7 July	50	14.5*		15
18 July	76	70.4		350
20 July	59	17.8		36
8 Aug.	68	43.4		188
10 Aug.	60	17.6		34
11 Aug.	78	42.1F		160
1 Sept.	57	25.4		81
7 Sept.	65	32.6		124
23 Sept.	77	71.7F		322
24 Sept.	59	24.7		76
28 Sept.	48U	15.8*		24
10 Oct.	80	55.3F		232
13 Oct.	58	31.5		118
18 Oct.	80	56.1F		236
21 Oct.	48U	13.7*	331	9
26 Oct.	69	35.4*F		123
28 Nov.	50	18.7*F		31
30 Nov.	59	48.6*F		195
30 Nov.	69	31.4†		116
5 Dec.	70	37.6F		135
6 Dec.	48	18.9†F		33
9 Dec.	56U	31.6		118
9 Dec.	69	33.8		131
12 Dec.	49	17.1	316	23
21 Dec.	83	54.6F		228
1956				
4 Jan.	59	24.5F		63
12 Jan.	50	25.4F		68
13 Jan.	82	51.0*F		208
19 Jan.	70	55.2†F		231
30 Jan.	59U	32.0		120
7 Feb.	68	45.6	323	179
18 Feb.	81	67.3	294	298
27 Feb.	91	85.1F		395
28 Feb.	52	23.5	306	58
29 Feb.	50	16.1†F		17
8 Mar.	48	23.4F		57
16 Mar.	66	35.4	312	123
26 Mar.	94	59.6†F		255
30 Mar.	83	70.9F		317
9 Apr.	95	40.5	313	151
10 Apr.	68	37.8	306	136
30 Apr.	49	18.6	393	
7 May	66	36.8	307	131
16 May	83	53.1	240	220
21 May	49	17.2	352	37
27 May	92	58.0	326	247
5 June	80	51.4	296	211
8 June	65	14.0†	314	6
11 June	94	52.0	308	214
19 June	54	16.4	593	
21 June	68	14.2*	316	7
21 June	88	48.9	339	222
24 June	80	41.9	326	159
2 July	80	41.8	282	158
6 July	65	39.4	307	145
12 July	50	17.5	325	25
16 July	90	38.1	443	
1 Aug.	71–61	28.3	573	
5 Aug.	50	15.8	595	
13 Aug.	80	43.1	412	
30 Aug.	90	63.5F		277
12 Sept.	65	31.9	305	104
14 Sept.	90	54.8	349	265
18 Sept.	80	46.6	289	184
23 Sept.	50U	18.3	282	29
2 Oct.	52U	25.9	354	91
12 Oct.	66	32.6	312	108
16 Oct.	84	55.6	336	259
19 Nov.	80	52.4	395	
23 Nov.	66	12.8	314	−1
27 Nov.	48	13.3	331	7
13 Dec.	52U	31.8	328	113
20 Dec.	83	39.6	408	
1957				
10 Jan.	67	69.0	311	307
29 Jan.	90–85	65.1	324	286
6 Feb.	50U	14.9	529	
13 Feb.	82	63.3	308	274
19 Feb.	67	57.5	322	244
9 Mar.	68	59.4	356	300
17 Mar.	47	29.5	351	112
30 Mar.	83	47.1	341	212

Collection date	Altitude (10^3 ft)	Observed specific activity (disintegration/min per g of carbon)	Measured CO_2 concentration (ppm)	Excess C^{14} (10^6 atom/g of air)
10 Apr.	84	43.4	322	167
14 Apr.	67	55.5	460	
15 Apr.	48	28.0F		82
25 Apr.	48U	26.4F		74
27 May	63	28.1	392	
28 May	49	16.2*F		18
29 May	73	46.9	308	186
19 June	91	37.2	365	169
20 June	76	50.4F		205
27 June	50	24.1F		61
11 July	50	15.4		13
11 July	62	33.7F	356	141
15 July	77	57.2F		242
19 July	85–82	48.5	363	240
23 July	65	32.5	348	128
2 Aug.	49U	11.3*	370	3
10 Aug.	90	38.6	376	183
16 Aug.	71	59.2F		253
22 Aug.	82	50.3F		205
24 Aug.	65	53.9F		224
4 Sept.	46	16.2	334	27
6 Sept.	77	47.1	407	
25 Sept.	89	58.0F		247
2 Oct.	79	46.5	316	184
2 Oct.	49	16.6	342	29
26 Oct.	65	62.8*F		273
29 Oct.	90	50.1F		203
5 Nov.	91	47.9		214
7 Nov.	108–105	41.6	333	173
25 Nov.	79	50.7	327	207
26 Nov.	50	16.7	326	20
30 Nov.	64	51.1F		209
4 Dec.	47	21.0F		44
12 Dec.	81	49.4F		200
19 Dec.	88	51.5F		211
21 Dec.	64	45.1F		176
1958				
8 Jan.	48U	15.2	328	17
10 Jan.	64	47.1F		187
22 Jan.	78	49.1F		198
31 Jan.	92	40.2	369	190
5 Feb.	90–88	49.8	328	217
7 Feb.	77	51.3F		210
13 Feb.	46	25.5	353	88
20 Feb	64	44.9*F		175
6 Mar.	47	19.1		43
12 Mar.	64	38.9	340	162
25 Mar.	81	42.4F		161
26 Mar.	93	41.1	341	176
7 Apr.	90	44.6		195
8 Apr.	78	47.1F		187
9 Apr.	47	33.6F		113
16 Apr.	65	48.5†F		195
9 May	91	45.2F		177
12 May	48	23.2F		56
15 May	78	38.8F		142
6 June	91	28.9		202
7 June	62	49.8†F		101
11 June	47U	25.3F		68
17 June	77	47.8F		191
20 June	61	40.9F		153
San Angelo, Tex. (lat. 32° N)				
1955				
22 Mar.	50U	15.9		21
24 Mar.	62	26.8		85
29 Mar.	71	70.7		339
30 Mar.	74	64.4		303
5 Apr.	62	25.7		78
8 Apr.	72	50.8		224
14 Apr.	78	68.5		327
21 Apr.	53–51	15.1		17
25 Apr.	71	41.7		171
13 May	70	42.8*		177
14 May	53–50U	16.6		25
16 May	79	72.6		350
17 May	63	20.4		48
23 June	71	44.8		189
5 July	77	48.7		212
12 July	61	20.2		47
2 Aug.	53–51	14.9†		16
3 Aug.	70	31.1		109
7 Aug.	59	20.7		49
10 Aug.	78	40.1		162
8 Sept.	71	28.8		96
9 Sept.	60	17.2*		29
27 Sept.	77	40.6		164
28 Sept.	93	62.2		290
29 Sept.	93	62.7		293
19 Oct.	71	21.3		53
25 Oct.	60	20.4		48
3 Nov.	83–80	42.7	323	163
4 Nov.	71	54.1	301	225
9 Nov.	50	20.8	299	43
21 Nov.	62	20.1	310	39
25 Nov.	81	55.8*	376	299
4 Dec.	51	13.1	377	16
7 Dec.	62	25.3	382	100
10 Dec.	82	48.2	329	208
12 Dec.	72	37.7	331	149
1956				
25 Jan.	50U	15.2	312	12
6 Feb.	84	56.1	325	236
20 Feb.	66	29.7	310	92
8 Mar.	69	12.5*	303	− 3
16 Mar.	83	63.2	316	275
22 Mar.	50	15.7	291	15
23 Mar.	98	69.8	311	311
4 Apr.	95	69.6	336	341
14 May	52–51	13.2	320	1
16 May	68–63	40.7	617	
17 May	84	58.1	314	247
8 June	50U	15.7†	313	15
18 June	65	28.9	327	87
19 June	81	50.7	338	231
6 July	52	16.0	398	
8 July	83	44.5	351	204
18 July	66	28.3	373	115
22 July	93	51.8	379	275
6 Aug.	47T	14.4	556	
7 Aug.	65	38.1	619	
9 Aug.	84	41.5	483	
11 Aug.	94	57.8	331	266
25 Aug.	94	52.2	328	231
5 Sept.	80	48.1	405	
7 Sept.	94	23.6	475	
8 Sept.	50T	14.2	388	26
11 Sept.	65	27.1	333	87
5 Oct.	96	44.8	374	224
11 Oct.	65	32.1	480	
16 Oct.	79	34.2	1880	
22 Oct.	47T	13.3	690	
6 Nov.	94	53.6	312	223
13 Nov.	66	38.2	312	138
16 Nov.	44	13.4*	329	6
17 Nov.	77	51.7	298	212
15 Dec.	63	40.5	500	
17 Dec.	95	52.6	307	217
1957				
12 Jan.	100	44.7	427	
17 Jan.	67	42.8	381	216
1 Feb.	97	42.5	308	162
10 Feb.	80	69.7	304	311
25 Feb.	67–65	30.6	348	117
7 Mar.	96	46.4	338	205
12 Mar.	81	68.7	340	340
18 Mar.	50	13.9*	411	
23 Apr.	81	51.2	340	235
29 Apr.	66	52.9	321	219
2 May	82	65.5	310	288
3 May	66	43.4	294	167
19 May	89–87	45.0	243	176
21 May	49U	13.8*	301	5
6 June	91	49.5	311	200
10 June	67	44.2	296	171
12 June	48U	15.7*	326	15
19 June	82	57.4	343	275
7 July	88	56.7	392	
9 July	67	36.3	306	128
11 July	85–78	55.9	296	235
13 July	48	14.0	302	6
6 Aug.	65	37.7	364	171
7 Aug.	91	38.2	483	
9 Aug.	82–78	58.4	308	249
20 Aug.	50	14.8	418	
4 Sept.	90	53.2	333	241
6 Sept.	81	40.1	306	149
11 Sept.	65	24.4	383	94
13 Sept.	49	13.7	376	20
1 Oct.	50	10.1*	402	
3 Oct.	91	27.7	475	
4 Oct.	83	54.1	323	225
5 Oct.	65	24.4	337	74
2 Nov.	90	57.7	311	245
14 Nov.	48	19.5	309	36
20 Nov.	84	39.6	309	146
26 Nov.	66	46.9	310	186
2 Dec.	82–80	54.3	313	226
4 Dec.	49T	13.2	306	1
7 Dec.	90	55.4	315	232
10 Dec.	67	40.0	320	148
1958				
7 Jan.	81–79	55.6		252
8 Jan.	90	46.5	348	214
9 Jan.	50	15.5	349	24
15 Jan.	62	42.7	331	178
1 Feb.	50U	13.5*	324	3
2 Feb.	92	49.2	330	215
7 Feb.	65	40.5	309	151
15 Feb.	80	49.7	313	201
3 Mar.	92	43.0*	311	165
7 Mar.	80	49.4	314	200
9 Mar.	67	41.7	308	157
10 Mar.	51U	19.2	309	34
1 Apr.	92	42.3	317	161
3 Apr.	65	28.9	315	87
7 Apr.	82	47.6	313	190
8 Apr.	49	14.8	318	10
3 May	48U	20.2*	318	40
4 May	66	36.5	317	129
7 May	92	45.7	312	179
10 May	49	26.0	314	71
19 May	81	53.3F		221
3 June	81	47.2		204
5 June	89	43.6F		168
7 June	65	47.2		204
8 June	52U	13.5†F		3
2 July	82	46.7F		185
3 July	67	41.3F		155
12 July	50U	24.0F		60
18 July	89	45.3		192
1 Aug.	50U	16.8*		27
2 Aug.	92	44.7		189
3 Aug.	66	38.8		155
5 Aug.	81	52.7F		218
1 Sept.	90	47.4F		189
3 Sept.	80	49.2F		199
4 Sept.	51U	17.7F		26
9 Sept.	66	38.0F		137
Canal Zone, Panama (lat. 9° N)				
1955				
30 Mar.	75	29.7		112
31 Mar.	50–48T	12.3*		4
11 May	69	21.5		61
12 May	63	12.1*		3
27 May	79	40.3		177
11 June	51U	13.4†		11
13 June	61	13.1		10
29 June	79	36.3		152
30 June	70–69	19.2		47
7 July	78	32.3		127
18 July	51T	14.0		15
28 July	62	14.0*		15
30 July	70	13.7†		13
6 Aug.	77	27.5		98
9 Aug.	60	17.8		39
26 Aug.	52	13.4		11
10 Sept.	77	16.6*		31
13 Sept.	70	12.9*		9
22 Sept.	94–91	46.5		215
18 Oct.	92–89	44.2		200
28 Oct.	77	26.3		90
30 Oct.	61	14.9*		21
2 Dec.	83	26.1	317	72
11 Dec.	51T	3.2†	1500	
14 Dec.	71	18.2	367	47
1956				
20 Jan.	50T	11.1*	336	− 5
21 Jan.	62	15.4	325	13
12 Feb.	62	18.6	325	31
3 Mar.	52T	12.0*	321	− 5
4 Mar.	71	11.7*	355	2
14 Mar.	51	11.7*	345	0
28 Mar.	80	22.3	309	51
4 Apr.	52T	11.2	341	− 4
5 Apr.	68	19.7	317	37
9 Apr.	82	18.0	309	28
10 Apr.	93	20.7	307	42
6 May	50T	12.2	368	8
15 May	81	17.8	396	
22 May	61	16.6	422	

Collection date	Altitude (10^3 ft)	Observed specific activity (disintegration/min per g of carbon)	Measured CO_2 concentration (ppm)	Excess C^{14} (10^5 atom/g of air)
1 June	51U	12.5*	351	6
11 June	66	16.7	439	
15 June	82–80	19.2	716	
6 July	55	11.2†	365	1
7 July	67	23.4	326	57
1 Aug.	67	32.7	336	122
7 Aug.	54T	12.2*	301	– 4
4 Sept.	52	12.7*	329	3
6 Sept.	69–66	91.3	343	480
4 Oct.	97–90	27.5	534	
15 Oct.	67	37.1	381	178
16 Oct.	54	11.0†	338	– 6
21 Oct.	87–83	35.3	295	122
1 Nov.	51T	11.9*	348	2
1 Nov.	70	50.4	321	205
19 Nov.	92	29.2	350	109
27 Nov.	81–79	34.7	330	131
1 Dec.	52T	10.7*	382	1
4 Dec.	93–88	29.8	359	117
10 Dec.	67	24.1	372	87
1957				
20 Feb.	84–82	47.5	361	231
21 Feb.	51T	11.3*	352	– 1
22 Feb.	66	17.7	343	36
1 Mar.	77	28.2	552	
3 Mar.	65	12.3†	377	10
4 Mar.	47T	3.9†	459	
7 Mar.	91–87	29.1	341	103
4 Apr.	82	57.1	388	319
11 Apr.	66–64	15.3*	296	13
13 Apr.	50T	10.3*	374	– 4
4 May	65	10.9	351	– 3
7 May	49T	9.5	353	– 12
10 May	78	43.6	316	167
22 May	65	11.2†	378	3
7 June	81–79	47.3	361	230
9 June	65	22.4	309	52
1 July	49U	12.5*	355	7
14 July	67	26.6	321	75
19 Aug.	66	23.2	368	79
20 Aug.	50U	13.2	424	
20 Sept.	65	21.6	327	47
8 Oct.	89	48.4	324	194
21 Oct.	49T	12.9	322	0
23 Oct.	67	20.4	312	40
30 Oct.	80	29.4	321	90
1 Nov.	82	29.7	534	
3 Nov.	89	27.1	324	77
5 Nov.	52T	13.2	319	1
6 Nov.	66	24.1	319	61
1 Dec.	46T	12.2	319	– 4
2 Dec.	90–88	31.0*	363	127
4 Dec.	66	20.9	396	
15 Dec.	78–76	27.9	323	81
1958				
2 Jan.	51T	10.8†	334	– 8
5 Jan.	81	28.1	381	118
13 Jan.	92	37.0	338	140
15 Jan.	65	40.2	348	145
5 Feb.	67	26.2	327	73
10 Feb.	82	30.7	327	97
16 Feb.	93	18.9	515	
4 Mar.	92	30.3	347	114
8 Mar.	50T	12.3†	347	4
1 Apr.	94	39.9	358	181
3 Apr.	52T	13.1*	401	
4 Apr.	81	37.6	369	173
14 Apr.	65	10.0†	512	
1 May	65	22.9	322	54
2 May	51T	14.6	348	19
4 May	85	33.2	334	124
9 May	80	42.2	337	179
2 June	65	24.4	328	70
6 June	81	45.7	380	234
8 July	61	44.9	332	192
14 July	51U	11.3*	459	
1 Aug.	65	183.3	313	933
6 Aug.	51T	15.6	244	14
3 Sept.	65	64.6F		283
8 Sept.	52	14.3		16
São Paulo, Brazil (lat. 23° S)				
1955				
22 Mar.	61	13.4*		6
29 Mar.	50T	13.9*		9
17 Apr.	62	12.7*		3
26 Apr.	79	25.1		73
27 Apr.	70	17.3		29
28 Apr.	52T	14.3*		11
9 May	78	22.4		58
11 May	60	13.2*		1
12 May	50U	12.9*		4
27 May	69	15.2*		16
14 June	78	21.8*		54
15 June	61	12.8†		3
5 July	79	24.2		69
7 July	71	16.0		21
10 July	62	11.2		– 7
3 Aug.	78	21.2*		51
6 Aug.	61	14.7		14
30 Aug.	70	14.5		12
14 Sept.	60	12.9		4
28 Sept.	90	98.0		493
11 Oct.	91	105.7		537
12 Oct.	77	33.7		123
13 Oct.	68	17.9		32
30 Oct.	61	14.4*	398	
1 Nov.	76	37.7	321	136
20 Nov.	69	20.6	305	42
25 Nov.	52U	15.3	301	13
26 Nov.	62	13.7†	317	4
2 Dec.	75–69	20.7	589	
6 Dec.	52T	11.7*	434	
7 Dec.	82–80	39.2	306	144
8 Dec.	62	15.7	308	15
27 Dec.	81	36.4	278	128
1956				
10 Jan.	62	15.6*	375	31
11 Jan.	71	17.6	292	25
12 Jan.	81	39.3	298	144
16 Jan.	52T	13.4†	285	2
1 Feb.	52T	13.5	308	3
6 Feb.	62	14.7	300	10
7 Feb.	69	22.3	305	51
24 Feb.	81	26.9	327	76
5 Mar.	80	26.2	281	73
13 Mar.	52T	12.8	276	– 1
14 Mar.	70	17.7	307	26
3 Apr.	83–81	21.7	380	74
26 Apr.	96	33.7	399	
27 Apr.	53–50U	12.8†	296	– 1
18 May	81	18.1	298	28
19 May	68–65	15.6	291	14
20 May	91	22.0	313	50
21 June	51	14.5	310	8
23 June	68–65	25.2*	377	96
30 June	80	19.3	380	59
17 July	50U	15.1	517	
19 July	67–65	23.2	425	
20 July	80	47.4	429	
22 July	90	42.6	300	162
16 Aug.	92–90	23.7	292	59
17 Aug.	82–80	37.1	308	132
18 Aug.	50T	14.7	282	10
29 Aug.	68–65	26.4	310	74
11 Sept.	53–50U	15.1	304	12
12 Sept.	68–65	45.1	407	
15 Sept.	90	34.8	293	120
16 Sept.	80	30.7	380	134
2 Oct.	54–50U	13.8	326	5
4 Oct.	67–65	22.7	306	53
26 Oct.	90	24.5*	344	77
29 Oct.	81	50.8	322	207
30 Oct.	91	37.7	301	136
1 Nov.	90	19.8	314	37
19 Nov.	81	29.4	554	
10 Dec.	90–87	26.0	317	71
12 Dec.	90	27.5	332	90
21 Dec.	66	21.2	331	52
1957				
18 Jan.	90	43.2	344	191
28 Jan.	90	35.3	389	170
29 Jan.	84–80	33.4	424	
11 Feb.	93–90	36.1	419	
12 Feb.	83–80	32.8		118
16 Feb.	68–65	12.8*	468	
19 Feb.	50T	11.0*	379	2
19 Mar.	90	38.4	308	139
20 Mar.	80–78	24.7	303	64
25 Mar.	66	21.2	298	45
26 Mar.	50–46	13.1	295	1
10 Apr.	90	35.2	413	
25 Apr.	84	38.3	308	139
26 Apr.	68–66	19.0†	307	33
27 Apr.	49T	12.8*	313	– 1
14 May	65	19.4	313	35
15 May	95	39.5	297	145
17 May	81	39.6	320	146
18 May	50T	13.2	325	1
19 May	80	37.6*	308	135
31 May	80	47.0	301	186
1 June	90	37.9	404	
2 June	64	17.8	349	39
13 June	94	34.2	306	116
14 June	81–78	37.6	331	148
15 June	49T	12.2*	410	
9 July	66	15.8	481	
10 July	93	41.0	308	154
11 July	93	39.9	363	185
12 July	80–74	39.1	298	143
13 July	49U	14.3*	345	16
3 Aug.	68	33.7	298	114
5 Aug.	49U	16.2*	522	
8 Aug.	80	43.3	313	166
10 Aug.	90	39.7	495	
16 Aug.	89	35.4	357	152
17 Aug.	90	38.5	369	179
5 Sept.	49U	15.2*	339	20
6 Sept.	65	30.2	310	94
10 Sept.	80	39.3	311	144
12 Sept.	81	37.4	319	134
15 Sept.	87	36.1	314	127
21 Nov.	92	35.3	326	122
22 Nov.	82–75	37.7	316	136
24 Nov.	80	32.9	315	109
25 Nov.	65	28.4	322	85
10 Dec.	82–80	30.8	323	98
12 Dec.	66	32.2	320	105
14 Dec.	51U	12.7	312	– 1
19 Dec.	96–93	42.6	323	162
1958				
7 Jan.	79	28.5†	326	85
8 Jan.	89	36.9	323	131
10 Jan.	65	27.7	391	
11 Jan.	51U	12.4*	337	3
3 Feb.	66	25.9*	314	71
9 Feb.	80	39.7	304	146
10 Feb.	90	37.0	316	132
5 Mar.	80	38.4	313	139
6 Mar.	90	38.8	323	142
7 Mar.	80	35.4	312	128
13 Mar.	66	22.9	320	54
14 Mar.	50T	12.8	308	– 1
2 Apr.	52U	15.1	310	12
3 Apr.	69	34.4	325	117
4 Apr.	81	33.1	316	110
5 Apr.	90	34.7	314	119
9 May	65	23.0†	329	62
11 May	89	33.8	308	114
12 May	51T	13.9†	316	5
16 May	88	38.6	317	140
17 May	80	38.7	325	151
4 June	64	22.5	316	52
5 June	88	41.4	319	156
8 June	80	37.3		143
10 June	48T	15.5		18
13 June	79	40.8F		153
9 July	90	36.1F		127
10 July	63	33.3		120
11 July	80	36.3		138
13 July	52U	16.0		21
5 Aug.	93	37.5*F		134
7 Aug.	81	36.8		141
8 Aug.	53T	17.8F		27
9 Aug.	65	39.1		154
2 Sept.	95	31.9		113
4 Sept.	53U	13.2		5
Sioux City, Iowa (lat. 42.5° N)				
1958				
5 July	50U	17.7	314	26
6 July	66	47.3	301	188
7 July	81	46.1	369	229
2[illegible] July	93	45.2*	334	195
2 Aug.	90–88	43.7	317	168
3 Aug.	66	45.5	313	178
7 Aug.	49	19.2F		34
9 Aug.	80	48.7F	315	196
1 Sept.	88	44.5	329	187
1 Sept.	50U	17.6	311	25
8 Sept.	62	40.3		150
15 Sept.	83	48.0		192

3) When the measured concentration was between 327 and 389 ppm, the specific activity was corrected by the following ratio: measured concentration/311.

4) No correction was made in the few cases in which the measured concentration was less than 295 ppm on the assumption that such low values were due to sampling errors which did not affect the specific activity.

5) Samples whose measured concentration was greater than 389 ppm were considered too unreliable to be used.

6) For samples for which no measurement of concentration was available, the specific activity values were corrected by the following factors, representing the ratios of the average of the measured values of the compressed air samples at each station (excluding values greater than 389 ppm) to 311 ppm: Minneapolis, 1.09; San Angelo, 1.06; Canal Zone, 1.12; São Paulo, 1.05; Sioux City, 1.00.

An investigation is being made of the C^{13}/C^{12} ratios of the carbon dioxide samples in the hope that more exact corrections may be applied to the data.

Column 5 of Table 2 lists what are considered to be the best values for the concentration of artificially produced carbon-14—that is, the excess over the natural cosmic ray-produced carbon-14 background, expressed in units of 10^5 atoms of carbon-14 per gram of air. These values were obtained from the measured specific activity values, which were corrected for variations in concentration in the manner just described and converted to units of 10^5 atoms per gram of air on the basis of a carbon-14 half-life of 5600 years and a uniform stratospheric concentration of carbon dioxide of 311 ppm. The assumed natural background is 71×10^5 atoms of carbon-14 per gram of air, corresponding to a specific activity of 13 disintegrations per minute per gram of carbon. The uncertainty of this assumed stratospheric background is probably small compared to the magnitude of most of the excess carbon-14 observations and does not seriously affect the integrated inventory of artificially produced carbon-14 in the stratosphere.

These excess carbon-14 results are presented graphically in Fig. 3, which shows the measurements in four altitude groups as a function of time at the four collection stations. The lines connecting the points, especially in time regions of few measurements, are for visual aid only. Indicated at the top of the figure

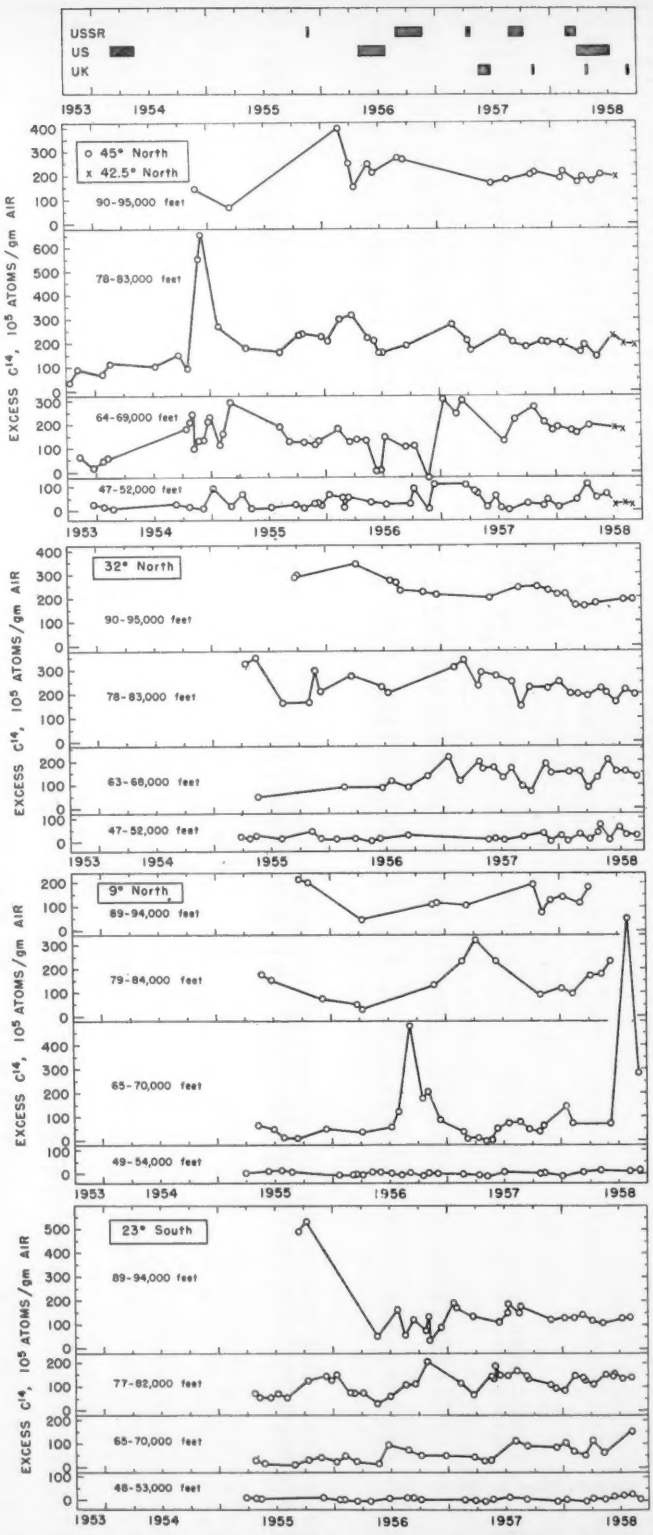

Fig. 3. Excess carbon-14 as a function of time at various altitudes and latitudes. Bars at top of figure indicate large stratospheric injections of radiocarbon by nuclear tests.

are the times of known large stratospheric injections of carbon-14 by nuclear detonations. These have been taken from the compilation of Telegadas (*5*). The detonations of each country are indicated separately. In the case of the United States, only the Pacific test series are shown. It should be borne in mind that the U.S.S.R. tests have been carried out north of 40°N; the U.S. tests have been carried out at 11°N; and the U.K. tests have been carried out primarily at 2°N. The lengths of the bars show the duration of the test series and do not necessarily bear any relationship to the amount of carbon-14 injected into the stratosphere.

Tritium

Sample processing and measurement. The recovered samples of water from the stratospheric air collections, usually 1 to 10 milliliters in volume, were split into two fractions. The concentration of the deuterium was measured in one fraction by mass spectrometric or infrared analysis, the concentration of the deuterium in the original tracer water having been determined previously. About 0.5 to 0.75 milliliter of the second fraction was reduced to hydrogen gas by magnesium, and the tritium content of the gas was measured with a Geiger counter surrounded by anticoincidence counters and steel shielding. The majority of the samples had counting rates at least one order of magnitude greater than background.

The total tritium collected was obtained by multiplying the tritium-to-deuterium ratio in the samples by the total deuterium added as tracer at the time of collection. The volume of air collected was estimated by measuring the total number of revolutions of the blower, which had been calibrated under simulated conditions, and by photographing the inflated collection bag to estimate its dimensions. The mass of air sample was calculated from the density of the air at the collection altitude.

Results and errors. The concentration of tritium per gram of air may be ascertained even though water is added or subtracted indiscriminately prior to the laboratory separation into the two fractions, provided that the added water contains no appreciable tritium or deuterium (tropospheric water would produce no significant error). However, the tritium-to-hydrogen ratio in the stratosphere is not determined by this method. It can only be inferred from the water vapor content of stratospheric air, which is poorly known.

Following is an evaluation of the errors associated with the tritium measurements. The amount of tracer added during the collection of the air is estimated to be accurate to about ±1 percent. The deuterium concentrations are accurate to ±4 percent. Errors in the measurement of the tritium activity are about ±10 percent; about half are attributable to statistical counting errors and half to calibration errors. The tracer deuterium oxide contained less than 250 disintegrations of tritium per minute per gram. This was normally only about 5 percent of the total tritium in a sample and, therefore, introduced only a small correction.

The method of determining the volume of air collected is estimated to have a standard error of about ±5 percent. However, the density must be known to convert the volume to mass of air and, due to uncertainties in the absolute altitude of the collection, the mass of air collected is not known to better than ±15 percent below 70,000 feet and ±25 percent above 70,000 feet. Thus, the error in determining the mass of air containing the tritium is the predominant error.

Combining all the sources of error, it is estimated that a single determination of the tritium concentration should be accurate to ±30 percent, with greater accuracy at the lower levels of the stratosphere.

A few early results were obtained in the period between June 1955 and August 1956 and are listed in Table 3. In these early collections, tracing was performed by adding deuterium oxide to the collection bag before the balloon was launched. The error associated with these measurements may be somewhat larger than the errors associated with similar measurements made during the period 1957–58 obtained by the collection method described above. The latter results are given in Table 4.

Discussion

General comments. Figure 3, showing the excess of carbon-14 at the four locations as a function of time, presents a different pattern at the different altitudes. The excess carbon-14 values are small at the lowest altitudes (approximately 50,000 feet) and show little fluctuation with time. On the other hand, the data at the higher altitudes show large excess carbon-14 concentrations and marked variability. Some of this variability may be due to experimental errors. However, several striking peaks —for example, those at the Canal Zone at 65,000 to 70,000 feet in September 1956 and July 1958—are closely related to known injections. On the other hand, the large peaks at Minneapolis at 80,000 feet in December 1954 and at São Paulo at 90,000 feet in October 1955, 6 and 16 months after United States tests in the Pacific, indicate a lack of homogeneity of the stratosphere long after the injection of the carbon-14 has occurred.

The concentrations at Minneapolis and San Angelo in the Northern Hemisphere are greater than at São Paulo in the Southern Hemisphere. Broecker and Walton (*6*) also found higher carbon-14 concentrations in Northern than in Southern Hemisphere tropospheric air.

Table 3. Tritium concentrations in 1955–56 in the stratosphere above Minneapolis.

Collection date	Altitude (10^3 ft)	Tritium (10^6 atom/g of air)
30 Nov. 1955	59	78
4 Jan. 1956	59	62
26 Oct. 1955	69	43
19 Jan. 1956	70	72
15 June 1955	76	82
11 Aug. 1955	78	140
23 Sept. 1955	77	115
10 Oct. 1955	80	89
18 Oct. 1955	80	38
26 Mar. 1956	94	86
30 Aug. 1956	90	107

Table 4. Tritium concentrations in 1957–58 in the stratosphere above Minneapolis.

Collection date	Altitude (10^3 ft)	Tritium (10^6 atom/g of air)
28 May 1957	49	11
27 June 1957	50	25
11 July 1957	50	9
6 Mar. 1958	47	27
9 Apr. 1958	47	42
16 Aug. 1957	71	118
24 Aug. 1957	65	107
26 Oct. 1957	65	111
30 Nov. 1957	64	89
21 Dec. 1957	64	123
10 Jan. 1958	64	89
20 Feb. 1958	64	69
7 June 1958	62	58
20 June 1958	61	85
20 June 1957	76	71
15 July 1957	77	107
22 Aug. 1957	82	59
22 Jan. 1958	78	68
7 Feb. 1958	77	71
25 Mar. 1958	81	73
15 May 1958	78	67
17 June 1958	77	152
25 Sept. 1957	89	124
5 Nov. 1957	91	61
19 Dec. 1957	88	99

A final observation from Fig. 3 is the higher average values at Minneapolis and San Angelo than at the Canal Zone at almost all altitudes and times covered by this study. This is particularly striking in view of the large injections by the United States in the latitude closest to the Canal Zone. The significance of this observation is discussed below.

Stratospheric inventories (*7*). The data permit estimates of the stratospheric content of radiocarbon produced by nuclear weapons. In computing these inventories, charts such as Fig. 4 were prepared from concentrations averaged over 6-month intervals centered on 1 January and 1 July. The stratospheric content was found by graphical integration and is given in Table 5. It is felt that the errors in these numbers are no greater than ±30 percent.

Münnich and Vogel (*8*) have estimated that there were about 4.4×10^{27} artificially produced carbon-14 atoms in the troposphere, the biosphere, and the surface layers of the oceans in mid-1957. Broecker and Walton (*6*) estimate the number to be 4.8×10^{27} carbon-14 atoms in March 1958. Correcting these numbers to 1 January 1957, using an average of the growth curves for the two hemispheres given by Broecker and Walton, gives about 3.2 and 2.4×10^{27} atoms, respectively. The same figures, corrected to 1 July 1958, are 6.8 and 5.2×10^{27} carbon-14 atoms. Since Broecker and Walton have more reliable estimates of the oceanic content, numbers near the lower part of the range are probably to be preferred. Thus, the total content in the stratosphere, troposphere, biosphere, and oceans was about 9.0×10^{27} carbon-14 atoms on 1 January 1957 and about 14×10^{27} carbon-14 atoms on 1 July 1958. [Libby (*9*) suggests that some carbon-14 may fall back to the ground or sea as calcium carbonate. This local fallout of carbon-14 is not included in the above inventories.] The 1 January 1957 inventory agrees with Libby's estimate (*9*) of about 10×10^{27} atoms produced by nuclear devices.

Table 5. Stratospheric content of artificial radiocarbon.

Date	Radiocarbon content (10^{27} C^{14} atoms)
1 July 1955	8.6
1 January 1956	8.0
1 July 1956	5.6
1 January 1957	6.6
1 July 1957	7.4
1 January 1958	6.1
1 July 1958	8.4

The 9×10^{27} carbon-14 atoms present on 1 January 1957 were produced by a total of 89 megatons of nuclear explosives (*10*). During the period 1957–58, an additional 85 megatons (*10*) were detonated. However, a larger fraction (85 percent versus 30 percent) of the tests were conducted in the air in the latter years and, therefore, probably introduced more carbon-14 per megaton into the atmosphere. For this reason, the increment in 1957–58 is estimated as roughly 16×10^{27} carbon-14 atoms. The sum, 25×10^{27} carbon-14 atoms, is the present estimate based upon available data of the total number of artificial radiocarbon atoms released into the atmosphere up to the suspension of atomic tests on 31 October 1958.

The fate of artificially produced carbon-14 is of importance in considering the biological hazards from atomic tests. According to Broecker and Walton (*6*), the carbon-14 content of the Northern Hemisphere troposphere had increased by 17 percent by mid-1958. If the 25×10^{27} carbon-14 atoms that have been produced up to the present were mixed throughout the world atmosphere only, the total tropospheric concentration of carbon-14 would be 1¾ times the natural concentration. However, it is not likely that this total will exceed 1½ times the natural concentration because of uptake by the oceans. Continued mixing (*11*) with the surface layers of the oceans will reduce the carbon-14 concentration in the atmosphere from the peak value to a world-wide average of about 1⅓ times the natural value. The bulk of the exchangeable carbon reservoir lies in the deep oceans, where there is over 50 times more exchangeable carbon than in the atmosphere. The mixing between the surface layers of the ocean and the deep ocean probably takes place over a period of several tens to several hundreds of years. Thus, it is estimated that mixing of the artificial radiocarbon with the entire global reservoir over many tens or hundreds of years will reduce the radiocarbon increment from nuclear tests carried out to the present date to below 1 percent of the natural background. The biological significance of increases in the carbon-14 content of the atmosphere has been discussed by Leipunsky (*12*), Pauling (*13*) and Totter *et al.* (*14*).

Some meteorological comments. The carbon-14 measurements afford a remarkable opportunity to study stratospheric motions. The radiocarbon observations pre-date the stratospheric measurements of particulate fission products (*15*). In addition, carbon-14, in the form of gaseous carbon dioxide, is a better tracer than the particulate fission products because there is little likelihood of separation from its associated air mass by gravitational settling or other mecha-

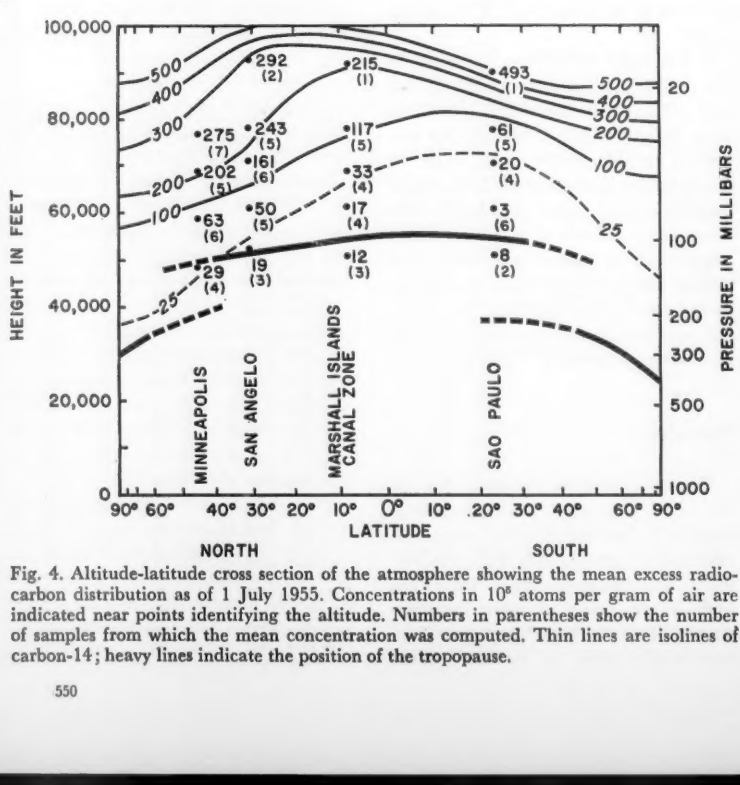

Fig. 4. Altitude-latitude cross section of the atmosphere showing the mean excess radiocarbon distribution as of 1 July 1955. Concentrations in 10^3 atoms per gram of air are indicated near points identifying the altitude. Numbers in parentheses show the number of samples from which the mean concentration was computed. Thin lines are isolines of carbon-14; heavy lines indicate the position of the tropopause.

nisms. Only a few of the meteorological interpretations of the data are presented below.

Figure 4 depicts the distribution of artificial radiocarbon as a function of altitude and latitude as measured during the period from April through September 1955. The analysis for the atmosphere north of 45°N and south of 23°S is subjective. The period April–September 1955 was chosen for discussion because all significant stratospheric injections prior to this date occurred at 11°N. For all practical purposes they originated from only two test series, that in the fall of 1952 and that in the spring of 1954. The cross section for July 1955 (Fig. 4) is thus based on samples collected more than 1 year after the second and larger injection.

Two of the significant features of Fig. 4 are (i) the greater concentrations at the same altitudes at the San Angelo and Minneapolis locations than at the Canal Zone and (ii) the higher concentrations at San Angelo, Minneapolis, and the Canal Zone than at São Paulo, except for the 90,000-foot levels, for which there are very few measurements. There appear to be two possible explanations of the distribution shown in Fig. 4 from a source which originated closest in latitude to the Canal Zone.

The first explanation assumes that the transfer of matter in the stratosphere takes place only by diffusive mixing along the gradient of concentration. Since the Canal Zone is close to the latitude of the source, the highest concentration on such a theory must always be present at this observing point relative to the other three stations. But, since the data indicate otherwise—namely, that the Canal Zone has lower concentrations level for level than San Angelo and Minneapolis—it is necessary to locate the highest concentrations above the highest altitude of the measurements, that is, above 90,000 feet. From these hypothetical high concentrations over the Canal Zone the radiocarbon mixes laterally either horizontally or along surfaces which slope gradually downward toward the poles. If the former, then vertical mixing is assumed to become more intense at the latitudes of the other stations. To account for lower concentrations at São Paulo than at San Angelo or Minneapolis north-south mixing across the equator must be assumed to be slow. The diffusion explanation may be reasonable since several powerful nuclear explosions were known to have risen beyond 90,000 feet

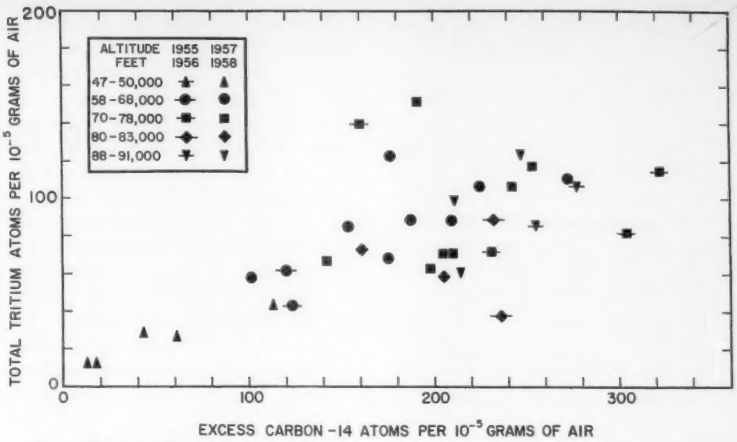

Fig. 5. Relationship between total tritium and excess carbon-14 in the stratosphere.

and, in general, higher concentrations are observed at increasing altitudes at all locations. It may be objected to on the grounds that the greatest lateral extent of the visible clouds, even for those which rose very high, may have been below 90,000 feet although the gases could be concentrated at the top of the mushroom. Further, high values at Minneapolis in December 1954 appear at 80,000 rather than at 90,000 feet. Finally, it is always unsatisfactory to explain something by unknown data just beyond the reach of observations.

The alternate explanation follows the Brewer-Dobson (*16*) model, as interpreted by Stewart (*17*) and Machta (*18*). Air is presumed to rise very slowly into the equatorial stratosphere from the troposphere, then drift upward and poleward. Each hemispheric branch is approximately symmetrical with respect to the geographical equator. Later, air descends into the lower stratosphere in the temperate or polar zone, or both. In this picture, the radiocarbon injections can take place below 90,000 feet. During the year following the 1954 tests, the northward drift bodily carried peak concentrations poleward in the Northern Hemisphere, leaving much smaller concentrations at the Canal Zone. Turbulent mixing is present in the stratosphere, but the transport is dominated by the circulation. Horizontal mixing across the equator brought a small amount of radiocarbon into the Southern Hemisphere for transport to the upper levels over São Paulo by the Southern Hemisphere circulation. This explanation is supported by the continued decrease of concentrations at the higher stratospheric altitudes over the Canal Zone until the summer of 1956, when new equatorial injections took place.

Another meteorological item of current interest is the residence time of air masses in the stratosphere before mixing with the troposphere. It has often been assumed that first-order kinetics can be applied to this exchange mechanism—that is, that the amount of a tracer removed from the stratosphere is always a fixed proportion of the stratospheric inventory. It is implied in first-order kinetics that the reservoir (in this case the stratosphere) is thoroughly mixed on a time scale shorter than that of the removal process. The nonhomogeneous stratospheric distribution more than a year after the injection (Figs. 3 and 4) argues strongly against a hypothesis of fast mixing. However, there is interest in knowing what fraction of the carbon-14 came out of the stratosphere during the early years. It should be noted that this fraction need not be the same for later years or for the first few years following an injection into the stratosphere at other latitudes and altitudes. Most of the carbon-14 prior to 1957 was added at 11°N.

Calculation of the stratospheric removal rate from differences in the total stratospheric contents at successive times is unreliable because of the inaccuracies in the inventories and the uncertain magnitudes of the injections of carbon-14 occurring during the periods considered. Instead, two other methods will be used.

On 1 January 1957 the total artificial radiocarbon inventory was about 9.0×10^{27} carbon-14 atoms, of which 6.6×10^{27} were still in the stratosphere. The fraction of the total remaining in the strato-

sphere can be explained by using known times and relative magnitudes of stratospheric injections (taking into account local fallout) and an exponential removal rate corresponding to about 17 percent per year. The mean stratospheric residence time on this basis is about 6 years (a half time for removal of 4 years).

A mean residence time in the stratosphere can also be calculated from the average stratospheric carbon-14 inventory and Broecker and Walton's growth curve for the troposphere (*6*). The stratospheric inventory is constant, almost within experimental error, at 7.2×10^{27} carbon-14 atoms during the period 1 July 1955 to 1 July 1958 (see Table 5). The average rate of increase of carbon-14 in the troposphere during this period was 1.2×10^{27} atoms per year (*6*). A very rough estimate of the average rate of uptake of the artificial carbon-14 by the oceans during the same period is 0.3×10^{27} atoms per year. This is based on a mean tropospheric content of 2.1×10^{27} atoms and a removal rate of one-seventh per year (*11*). Thus, about 1.5×10^{27} artificially produced carbon-14 atoms were removed from the stratosphere each year, corresponding to a mean residence time of slightly less than 5 years.

These residence times, about 5 years, are shorter than Libby's earlier estimate (*19*) but are close to the recent computations reported by Shelton (*20*), Libby (*21*), and Machta and List (*22*).

The uncertainty in the residence time as calculated in this paper is directly proportional to the uncertainty of the stratospheric inventory and depends to a lesser extent on the rate of uptake by the oceans. Further, it is assumed that all of the injections enter the stratosphere. A small error is made because some radiocarbon from weapons tests is inserted directly into the troposphere.

Comparison of tritium and carbon-14 measurements. Figure 5 is a plot of the total tritium as a function of the excess carbon-14 concentration at Minneapolis. It is evident that there is a positive correlation between the tritium concentration and the excess radiocarbon. On the assumption of a constant tritium to carbon-14 ratio from contributing nuclear explosions, the data can be used to calculate the natural tritium content of the stratosphere. The tritium concentration corresponding to zero excess carbon-14 is the natural tritium background value. Although only the 1957–58 points near the 50,000-foot level yield a statistically significant background value, 7×10^5 ($\sigma = 3.5 \times 10^5$) tritium atoms per gram of air, the entire body of the 1957–58 data gives a value consistent with this. If this concentration exists throughout the stratosphere, then there are approximately 6×10^{26} naturally produced tritium atoms in the entire stratosphere. Assuming that the mean stratospheric residence time is 5 years for natural tritium and that two-thirds of the natural production takes place in the stratosphere (as would be the case for cosmic ray production), 6×10^{26} tritium atoms lead to an average world-wide natural production rate of 1 tritium atom per square centimeter per second, in good agreement with recent estimates summarized by Begemann (*23*).

The tritium concentrations expressed as atoms per gram of air can be converted to tritium atoms per 10^{18} hydrogen atoms by estimating the stratospheric moisture content. The frost-point in the stratosphere is believed to lie in the range of $-65°$ to $-80°$C. Thus, the 50,000-foot background tritium concentration of 7×10^5 tritium atoms per gram of air would correspond to between 4×10^5 and 4×10^6 tritium atoms per 10^{18} hydrogen atoms. For comparison, rains in Chicago prior to 1954 contained 3 to 34 tritium atoms per 10^{18} hydrogen atoms (*24*).

The good correlation between the excess carbon-14 and tritium permits an estimate of the number of tritium atoms associated with each carbon-14 atom produced by weapon tests. Assuming that the ratio of tritium to carbon-14 atoms, 0.4, based on all of the 1957–58 data was the same at other locations than Minneapolis, the stratospheric inventory of excess tritium on 1 January 1958 was 2.4×10^{27} atoms, or about 4 times the natural content of tritium in the stratosphere. The rapid removal of tritium from the troposphere by precipitation puts most of nonstratospheric tritium in the oceans. Because of inadequate data on the tritium content of ocean waters, no attempt has been made to obtain a complete inventory of weapon-produced tritium.

References and Notes

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2. The collection equipment was developed by General Mills, Inc. Samples were collected by General Mills during the early period of work. Later, sampling was carried out by the Headquarters Command, U.S. Air Force. We gratefully acknowledge the assistance of the following personnel of the mechanical division of General Mills, Inc.: J. W. Swisher, D. Crowe, W. Borgeson, R. Dungan, J. Smith, R. Mautner, D. Dietsche, J. Gravelle, H. Demerest, and R. Stuart.
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News of Science

Congress Studies Research Programs To Develop Industrial Uses for Agricultural Products

In the present session of Congress, 25 "utilization research" bills have been introduced so far, five in the Senate and 20 in the House. Utilization research is the organized effort, through science and technology, to develop new uses for agricultural products, particularly uses in industry. It is offered as one solution to this country's continuing surplus of agricultural commodities. An example of effective utilization research is the development that occurred when detergents first replaced soap. A way was found to use the resulting surplus of animal fats by converting the fats into chemical compounds useful as plasticizers in vinyl plastics. Now 40 million pounds of animal fats are sold each year to make shower curtains, raincoats, garden hose, floor tile, and so forth.

Senator Homer Capehart (R-Ind.) led the way in proposing utilization research legislation in March 1956 when, joined by 30 of his colleagues, he introduced S.3503, the first of the current series of bills on the subject. In his proposed legislation, which he described in 1956 as the most important program he had ever sponsored in his tenure in the Senate, Capehart suggested the formation in the executive branch of the government of an Industrial Agricultural Products Administration. Many other plans have been offered since. At present, the two leading proposals are (i) the establishment of a new research agency within the Department of Agriculture and (ii) the creation of an advisory commission in the government's executive branch.

Capehart's original measure required a supporting appropriation of $100 million a year. He defended the amount by pointing out that despite the billions in federal funds being spent in price-support buying and in paying the farmer to reduce his acreage, the huge surplus was continuing to accumulate. What Capehart said in 1956 is still true today; yet only now, 4 years later, is a congressional proposal even approaching legislative sanction.

Bipartisan Commission Findings

In fact, the only constructive measure that has been passed was Public Law 540, under which the 84th Congress established a five-man bipartisan Commission on Increased Industrial Use of Agricultural Products. Employing 18 task groups to consider all the agricultural products useful or potentially useful to industry, the commission prepared a detailed report and submitted it to Congress in June 1957.

The commission concluded emphatically, that the United States economy can develop profitable industrial markets capable of absorbing enough of the excess farm production "to minimize, possibly even to eliminate, the need for costly restrictions, supports, and surplus-disposing operations." However, the report pointed out that four main needs must be met before such a development can be brought about. These were described as follows:

"The first [need] is a sufficiently sharp sense—lacking so far—of the importance, the possibilities, and the urgency of the industrial utilization approach to farm surplus problems.

"The second need is a greatly expanded program of fundamental and applied research—physical, chemical, biological, economic—to learn far more about the nature of agricultural raw materials and to determine what existing or new industrial products and processes might profitably use them . . . The research and development program would mobilize the efforts of many scientific institutions—private, public, State, Federal and perhaps even some in other countries. . . .

"The third need is to insure, through fellowships, scholarships, grants, and other means, that much more scientific talent is trained for and channeled into this neglected field of farm product research and development than it has engaged so far.

"The fourth need is to provide, in certain cases, suitable financial incentives during a temporary trial or development period—for example, new products or processes that are expensive to launch or that seem less promising than alternative uses of risk capital, or that might lead to especially rapid disposal of surpluses."

Present Program

At present the Department of Agriculture operates four regional utilization research laboratories, one in each major farm-producing area. These regional laboratories, which were established in 1938, are headquarters for the four Utilization Research and Development divisions of the Agricultural Research Service. Each division, including a number of associated field stations, conducts research on problems of national scope, with special emphasis on utilization of farm commodities important in its particular region.

The Northern Division, at Peoria, Ill., conducts research on corn, wheat, and other grains. The Eastern Division, at Wyndmoor, Pa., does work primarily on livestock and dairy products, fruits and vegetables, tobacco, and honey and maple products. The Southern Division, at New Orleans, La., conducts research on cotton, rice, sweet potatoes, sugar cane, peanuts, and so on. The Western Division, at Albany, Calif., investigates wheat, barley, poultry and eggs, sugar beets, wool, and alfalfa and other forage crops. Each of the laboratories has a staff of from 350 to 400 people, of whom about half are scientists. In fiscal year 1959 the four units spent $16,067,000.

Senate Proposes New Agency

Last month the Senate passed S.690, "To provide for the increased use of agricultural products for industrial purposes." This bill is identical to S.4100, which was passed last year too late for House action. The present bill, sponsored by senators Johnston, Proxmire, Humphrey, Talmadge, and Yarborough, would establish a new independent agency in the Department of Agriculture, to be known as the Agricultural Research and Industrial Administration, which would coordinate and expedite efforts to develop new uses for farm products, new crops to replace those in surplus, and additional means of disposing of surplus commodities in government inventory. The agency would be headed by an administrator under the general direction and supervision of the Secre-

tary of Agriculture and would hire up to ten scientists and technicians at rates higher than those allowed by the Classification Act.

To accomplish the objectives of the bill, the new agency would be empowered to utilize existing facilities and authorities; make research grants; use foreign currencies accumulated under Public Law 83-480 (the over-seas farm-surplus disposal program that has resulted in the accumulation of billions of dollars in unused funds abroad); enter into contracts or cooperative arrangements; make incentive payments; make Commodity Credit Corporation stocks available; provide for private operation of government facilities; assist in the acquisition or expansion of facilities by persons contracting or cooperating in research and development; grant exclusive licenses to use patents under the control of the Department of Agriculture; build, maintain, and operate manufacturing facilities; and provide for graduate scholarships and fellowships.

The authority granted the new agency would supplement, particularly with respect to putting research findings to industrial use, the broad powers already vested in the Department of Agriculture under the Research and Marketing Act of August 1946 and other statutes. The provisions granting the agency authority relative to grants, fellowships, scholarships, incentives for farmers and industry, and so on stem from recommendations of the Commission on Increased Industrial Use of Agricultural Products.

House Committee Favors Commission

The leading utilization research legislation in the House is quite different from that in the Senate, for it recommends the formation of an Agricultural Research and Development Commission as an independent organization in the executive branch. This suggestion, which was introduced in June as H.R.7576 (Abernethy), is the strongest House proposal on the subject. On 12 August the House Committee on Agriculture, having considered both H.R.7576 and Senator Johnston's bill for the creation of a new agency in the Department of Agriculture, ordered a moderately amended version of H.R.7576 reported out. The new version was reintroduced the same day by Abernethy (H.R.8639) and Dixon (H.R.8640).

The Agricultural Research and Development Commission would have seven members appointed by the President and confirmed by the Senate—four from agriculture and three from industry. Its responsibilities would be investigative and advisory. It would appraise agriculture's research needs and develop authoritative recommendations—that is, it would propose the initiation, expansion, termination, or redirection of agricultural and forestry research, with emphasis on utilization research. Its activities would include a review of the organizational structure of the Department of Agriculture's research program in order to make recommendations to the Secretary of Agriculture.

The commission would have whatever funds were necessary to conduct its work. It would meet at least four times a year, and it would issue detailed reports, including an annual one to the Secretary of Agriculture and to Congress. The executive director of the commission would be appointed by the Secretary of Agriculture from among persons nominated by the proposed commission.

A special section of the Abernethy-Dixon measure provides, further, that the Secretary of Agriculture be given certain additional powers in making grants and contracts for research intended to carry out the purposes of the new act.

Other Measures Introduced

The establishment of a new agency in the Department of Agriculture is the significant provision of ten of the 25 bills before the current session of Congress; in addition to Johnston's S.690, these are S.43, Mundt; S.74, Curtis; S.1124, Capehart *et al.;* S.1722, Title III, Capehart; H.R.2970, Brock; H.R.4167, Hemphill; H.R.7245, Wampler; H.R.7402, Flynn; and H.R.5234, Berry. The second largest group of bills is composed of the eight that recommend the expansion of utilization research under the Secretary of Agriculture within the existing organization: H.R.2380, Albert; H.R.2718, Abernethy; H.R.2719, Dixon; H.R.2720, McIntire; H.R.2766, Hoeven; H.R.2803, Steed; H.R.2880, Jennings; and H.R. 5441, Schwengel. These bills have had the strong support of the land-grant colleges, which would like to receive much larger research and equipment grants in order to greatly increase work in this field.

A third group, four bills, proposes the formation of an Agricultural Research and Industrial Board in the executive branch to coordinate and expedite utilization research: H.R.127, Kee; H.R. 309, Abernethy; H.R.2881, Jennings; and H.R.3070, Saund. Establishment of this board was another of the recommendations of the Commission on Increased Industrial Uses; it would have five members appointed by the President and confirmed by the Senate, one of whom must be an Assistant Secretary of Agriculture.

Department of Agriculture Views

The Department of Agriculture supports the Abernethy-Dixon legislation for an executive branch commission (H.R. 8639-40), maintaining that, with enough money and the appropriate authorizations, it can carry out the necessary program within its present organization. When asked to comment, a department spokesman said: "We can live with this one. With S.690, Sen. Johnston's bill, it would be difficult." He then emphasized that the House proposal established a group to aid the Secretary of Agriculture, a review body to determine what is needed, whereas S.690 creates a new administrative agency that would actually conduct utilization research, which would lead to a "complete shake-up—and what good would that do?" He pointed out that it would cost a great deal more to put the Senate proposal into effect, for presumably all of the department's established bodies would be transferred to the new agency. Furthermore, he added, under S.690 major problems would arise in the coordination of research programs and in competition for personnel.

These same views were expressed by Assistant Secretary of Agriculture E. L. Peterson when he testified this spring at hearings before the House Committee on Agriculture's Subcommittee on Research and Extension, which was considering 16 of the current bills. Peterson said:

"We opposed S.4100 [last year's identical predecessor of S.690] because it would have created an unnecessary agency to parallel and duplicate an already well-organized and well-established program in operation as a part of the total agricultural research effort. We believe that the present organization is fully capable of carrying out any expanded research program the Congress may authorize. . . .

"Research on the development of new uses for agricultural products is now conducted in a separate unit in the Department of Agriculture. This unit has no other responsibilities. The utilization research unit is separately budgeted and separately directed, but its efforts are

coordinated with all other research in the Department through the Administrator of the Agricultural Research Service and an Assistant Secretary of Agriculture."

Senate Attitude

Senator Capehart referred to the role of this "unit," the four regional laboratories, when he testified last year before the Senate Committee on Agriculture and Forestry on the six Senate bills on utilization research then pending. His remarks reflect the Senate opinion that a very large and spectacular separate program is the solution to the utilization research problem. Capehart said:

"Now you will have people who will testify here that the Department of Agriculture now has four laboratories . . . doing this work, and I agree that they are doing a good job. But it is not good enough in my opinion . . . We must move faster, appropriate more money, and have more people do this work . . . This year it is costing the taxpayer approximately $4 billion to support farm prices. It is costing another $365 million a year, a million dollars a day, to store the surplus."

This view was reconfirmed on 19 August by Secretary of Agriculture Ezra Taft Benson when he reported to the President that the mounting wheat surplus would increase the federal government's investment in that commodity to $3.5 billion next year. In July there was a wheat surplus of 1.3 billion bushels, and this amount is expected to increase. The cost to the government was reported to be $1.5 million a day for interest, storage, handling charges, and transportation. Although Benson presented these figures in support of a new economic program for agriculture, they constitute equally effective support for a utilization research program.

In the past 4 years of utilization research discussion, a frequently used device for emphasizing the urgency of the matter has been a comparison of the amounts industry and agriculture spend for research. Industry invests approximately $3 billion a year in research, 3 percent of gross sales. Agriculture invests some $375 million in research, about 1 percent of gross sales—and most of this is used to increase production. Federal and state governments spend $190 million of the total, of which no more than $18 million goes for utilization research.

Nearly half the market for natural fibers—cotton, wool, flax, silk—has been taken over by synthetic fibers. Two out of three pairs of shoes are now made partly or wholly of leather substitutes. As the Commission on Increased Industrial Use of Agricultural Products put it, "in recent years, agriculture has been researched out of a good part of its natural markets." The question is whether Congress will move this year—and, if so, in what direction—to increase the amount the government spends on utilization research for farm products.

Modern Methods Used to Test an Ancient Device

The Indian Government's Central Road Research Institute has developed a wheel tester, shown here, for studying the efficiency and durability of bullock-cart wheel-axis systems. The irregular lower wheel recreates road conditions by reproducing bumps and abrasions for the upper wheel, which is being tested.

The institute has a modern headquarters building in New Delhi that contains up-to-date research laboratories and facilities for developing and testing equipment. The organization has a wide range of activities, including the following: fundamental research on road-construction materials; soil mechanics studies; the development of standards and specifications for roads and road-building machinery; the design of road-testing instruments; the investigation of road characteristics under various traffic conditions; and surveys of accident rates, traffic volume, and so forth.

Old meets new: a modern efficiency test for an Indian bullock-cart wheel.

Eclipse Expedition Goes to Canary Islands

The U.S. National Committee for the International Geophysical Year of the National Academy of Sciences has announced that a joint expedition from Sacramento Peak Observatory, Sunspot, N.M., and the High Altitude Observatory, Boulder, Colo., will observe a total eclipse of the sun on 2 October from a site in the Canary Islands off the coast of Africa. The expedition is being given logistic support by the Geophysics Research Directorate of the Air Force Cambridge Research Center.

This expedition is one of four groups which will observe the eclipse as part of the follow-up to the International Geophysical Year known as International Geophysical Cooperation—1959. The expedition will make a second attempt to carry out experiments that were unsuccessful because of cloud cover during last October's IGY eclipse expedition to the Danger Islands in the Pacific.

The location for this year's observation site was selected in part because it offered the best chance of clear weather. It is at the southern tip of Fuerteventura in the Canary Islands. The Spanish Government has offered full cooperation.

The Sacramento Peak–High Altitude Observatory group hopes to observe a spectacular but very brief eclipse phenomenon known as the flash spectrum. More than 2 years were spent in preparing the equipment for studying this event, which lasts a maximum of about 50 seconds.

The flash spectrum occurs both at the beginning and at the end of eclipse totality. Parts of the sun's lower atmosphere, which ordinarily look dark against the bright background of the sun's disc, suddenly appear to flash out when the background is blocked off by the moon.

Also conducting studies of the eclipse will be teams from the University of Minnesota, the University of Wisconsin, the National Bureau of Standards Boulder Laboratories, and the Naval Research Laboratory. Paul Kellogg and Edward Ney of the Minnesota group, working in French West Africa, will seek to test their recently presented theory that the solar corona consists of trapped charged particles similar to the Van Allen radiation belt that rings the earth. Their work is supported by the National Aeronautics and Space Administration and the Office of Naval Research.

Wisconsin scientists on the Canary Islands will attempt to compile maps of the sun's corona and to obtain measurements farther out in the corona than ever before, in order to study change of temperature with height. Their project is supported by the National Science Foundation.

Other observations to be made will seek to determine the effects of the eclipse on the radio-reflecting qualities of the atmosphere and changes in oxygen airglow emissions in the upper atmosphere. Findings will be significant not only to basic research but also in preparation for future attempts to send instrumented rockets to the vicinity of the sun.

AEC Announces Program To Develop Thermal Breeder Reactors

The Atomic Energy Commission has initiated a long-range program to develop effective thermal breeder reactors that would make full use of the latent energy in thorium. Responsibility for the program, to be known as the Thermal Breeder Reactor Program, has been assigned to the commission's Oak Ridge Operations Office.

Thorium is an element which when bombarded with neutrons is converted to fissionable uranium-233. It is more abundant in the earth than natural uranium. However, there are fewer known reserves that can be exploited for commercial use than in the case of natural uranium.

A thermal breeder reactor is a reactor in which the nuclear chain reaction is sustained by neutrons moderated or slowed down to thermal (heat) energies and in which more fissionable material is produced than is consumed. In the initial loading of the thorium-uranium cycle, thorium is inserted in a reactor fuel with either uranium-235 or uranium-233, both fissionable materials. The chain reaction is sustained by the uranium while the thorium is converted to new uranium-233. The uranium-233 produced is then available to replace the fissionable material use during the reactor's operation.

The new program has as its objective the development of a thermal breeder reactor capable of converting thorium to fissionable fuel material at a doubling time of not more than 25 years. The term *doubling time* refers to the time necessary for a reactor to produce enough excess fissionable material to start up a second similar reactor.

The new program also involves a reorientation of work on the Fluid Fuel Reactor Program previously conducted for the commission by the Brookhaven National Laboratory (Upton, N.Y.) and the Babcock and Wilcox Company, Lynchburg, Va.) on the Liquid Metal Fuel Reactor (LMFR) concept and by the Oak Ridge National Laboratory (Oak Ridge, Tenn.) on the Aqueous Homogeneous Reactor (AHR) and Molten Salt Reactor (MSR) concepts. Much of the work on these projects has been directed toward the development of reactors of these concepts for the production of economic electric power. During fiscal year 1960, research and development on the AHR, MSR, and LMFR concepts, except as applicable to the new program, will be discontinued and there will be a transferral of financial support to the new program.

The commission's decision to reorient the Fluid Fuel Program towards implementation of the Thermal Breeder Reactor Program was based on the results of a study by a special task force of scientists and engineers convened by the commission in January 1959 to make a comparison of the reactor concepts included in the Fluid Fuel Program. As a result of task-force estimates of the power costs of large-scale fluid fuel reactors and of the cost and scope of research and development compared with estimates for other reactor concepts in advanced stages of development, the commission concluded that there is little incentive for further development of fluid fuel reactors as an approach to the attainment of low-cost nuclear power in the near future. Therefore, the commission decided to reorient its fluid fuel effort toward the use of the latent energy in thorium and natural uranium through a long-range development program. Because all three of the fluid fuel reactor systems were found by the task force to be potentially capable of develoment as breeder reactors, the new Thermal Breeder Program may include one or more of the concepts included in the Fluid Fuel Program.

In the initial phases, the new program will be a basic research and development effort and will include an evaluation of reactor technology to determine the most promising type of thermal breeder reactor for continued long-range development. Any work continued on present fluid fuel reactor concepts will be conducted in the framework of the broader Thermal Breeder Reactor Program.

Radiation Accident Described

A report on the medical care of five men who received large doses of radiation from the Y-12 plant accident at Oak Ridge National Laboratory in June 1958 has been released to the public by the Atomic Energy Commission through the Office of Technical Services, U.S. Department of Commerce. The publication is called *The Acute Radiation Syndrome: A Medical Report on the Y-12 Accident, June 16, 1958.* (Order ORINS-25 from OTS, U.S. Department of Commerce, Washington 25, D.C., $1.) This report provides a general account that not only relates the medical developments but also attempts to describe the events just as they occurred. Clinical developments are presented in rather complete detail. Separate sections give the results of serial hematological and biochemical studies, individual case histories, and a discussion of the acute radiation syndrome.

Grants, Fellowships, and Awards

General. The National Science Foundation has announced the Senior Postdoctoral and Science Faculty Fellowship programs. Awards will be made in the mathematical, physical, medical, biological, and engineering sciences. Also included are anthropology, psychology (excluding clinical psychology), and interdisciplinary fields (comprised of overlapping fields among two or more sciences). Selected social sciences are also included, under the Senior Postdoctoral Fellowship Program. Names of successful fellowship candidates will be announced on 7 December.

To be eligible for Senior Postdoctoral fellowships, candidates must be citizens of the United States with special aptitude for advanced training, and must have held the doctoral degree for at least 5 years or have equivalent education and experience. Candidates' qualifications will be evaluated by panels of scientists operating under the aegis of the National Academy of Sciences–National Research Council. Final selection of approximately 75 fellows will be made by the foundation.

The Science Faculty fellowships are awarded to college teachers of science, mathematics, or engineering who wish to improve their competence as teachers. These fellowships are open to any citizen of the United States who holds a baccalaureate degree or its equivalent, has demonstrated ability and special aptitude for science teaching and advanced training, has taught at the collegiate level as a full-time faculty member for not less than 3 years, and intends to continue teaching. Applicants' qualifications will be evaluated by panels of scientists appointed by the Association of American Colleges, but final selection of approximately 300 fellows will be made by NSF.

Annual stipends to a maximum of $12,000, adjusted to match as closely as possible the salaries of the recipients, will be awarded under both of these programs. Fellows may engage in study or research, or both, at any accredited nonprofit institution of higher education in the United States or at any accredited nonprofit foreign institution of higher education. A limited allowance to aid in defraying the cost of travel for a fellow and his dependents will also be available.

Application materials may be obtained from the Fellowships Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C. Completed materials must be received by *5 October.*

Teacher recognition. The National Science Teachers Association has announced the Science Teacher Achievement Recognition (STAR) awards program of 1960. STAR is conducted by NSTA under a grant from the National Cancer Institute of the United States Public Health Service. The purpose of the program is to encourage the development and reporting of new ideas in science in grades 7 through 12, thereby increasing the interest of high-school students in science.

In the 1958 competition, 369 entries were submitted from 45 states and territories. This year $13,500 in 56 awards will be given; in addition, certificates will be presented for entries which merit them. In previous years awards have been given for joint teacher-scientist entries. This year collaboration of scientists and science teachers will be encouraged by presentation of medallions to scientists who have contributed to award-winning entries.

The competition is open to all science teachers in junior and senior high-school grades in public and nonpublic schools. The deadline date for submission of entries is *15 December.* For further information and entry blanks, write to the STAR '60 Program, National Science Teachers Association, 1201 16th St., NW, Washington 6, D.C.

News Briefs

Britain's Department of Scientific and Industrial Research has announced that His Royal Highness the Duke of Edinburgh will open the new Ship Hydrodynamics Laboratory at Feltham on 19 October. The laboratory is an addition to the Ship Division of the National Physical Laboratory. The superintendent of the Ship Division is F. H. Todd, who returned to England in 1957 after 9 years in the United States as technical director at the David Taylor Model Basin, Washington, D.C.

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The Atomic Energy Act of 1954 has been amended to require that the Atomic Energy Commission report to the Congress on an annual basis instead of semiannually as heretofore. Therefore, the next formal report to Congress will be made in January 1960.

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A 99-year lease for a 14-acre site at Seibersdorf, 19 miles east of Vienna, Austria, on which the International Atomic Energy Agency will erect a functional laboratory, has been granted to the agency by an Austrian atomic energy research association known as SGAE. The laboratory will be used for standardization of radioactive isotopes and preparation of standards in the field of radioactivity; calibration and adaptation of measuring equipment; quality control of special materials for nuclear technology; measurements and analysis in connection with the agency's safeguards program (to insure that nuclear materials obtained through the agency are used only for peaceful purposes) and its health and safety program; and in connection with services to member states.

* * *

A unique journal that contains 11 research papers by high-school students was published at the University of Colorado this summer. Editor Edwin M. Fields, assistant director of the Academic Year Institute at the university, has sent the pilot issue of the *High School Science and Mathematics Journal* to high-school libraries in Colorado and Wyoming.

* * *

Atomic Energy of Canada Limited has announced that four more cancer treatment machines, together with their cobalt-60 radiation sources, have been shipped to the People's Republic of China. Two others were purchased from Canada last January. The total value of the shipments is $300,000.

Scientists in the News

PAUL HOWARD–FLANDERS, a member of the Medical Research Council, Experimental Radiopathology Research Unit at Hammersmith Hospital, London, has been appointed associate professor of radiology at Yale University School of Medicine.

Also at Yale, RUSSELL J. BARNETT, formerly assistant professor of anatomy at Harvard University, has been appointed associate professor of anatomy.

The Mary Soper Pope Medal of Cranbrook Institute of Science, Bloomfield Hills, Mich., for outstanding accomplishment in the plant sciences, was awarded posthumously to KENNETH W. NEATBY, geneticist, at the 9th International Botanical Congress.

LAURISTON C. MARSHALL, director of Research of the Link Belt Company, has been appointed associate technical director of the Microwave Power Laboratory of Varo Manufacturing Company, Inc., Garland, Texas.

CHARLES H. TOWNES, professor of physics at Columbia University, will receive a Stuart Ballantine Medal from the Franklin Institute on 21 October for his development of the maser.

WILLIAM E. ADAMS, James Nelson and Anna Louise Raymond professor of surgery at the University of Chicago, has been appointed chairman of the university's department of surgery. He succeeds DWIGHT E. CLARK, who died 24 July.

NATHANIEL I. BERLIN, head of the metabolism service of the General Medicine Branch, National Cancer Institute, National Institutes of Health, Bethesda, Md., has been appointed chief of that branch.

JOHN H. TALBOTT, professor of medicine at the University of Buffalo School of Medicine, has been appointed director of the American Medical Association's Division of Scientific Publications and editor of the *Journal of the American Medical Association.*

CHARLES F. SWINGLE, formerly of the U.S. Department of Agriculture, has been appointed head of the Arboretum of Tropical Agriculture of the newly established World Life Research Institute, Colton, Calif.

WILLIAM H. GOLDWATER, formerly of the biochemistry branch, U.S. Naval Radiological Defense Laboratory, San Francisco, Calif., has joined the Division of Research Grants, National Institutes of Health, Bethesda, Md., as executive secretary of the Metabolism Study Section.

HENRY ROBERTS, formerly group leader in charge of the chromatography section of the research and development division of the National Dairy Products Corporation, has been appointed senior research chemist at the Squibb Institute for Medical Research, section of analytical and physical chemistry.

ARNOLD M. BASS, assistant chief of the free radicals section of the National Bureau of Standards, has been appointed chief of that section. He succeeds HERBERT P. BROIDA, who is spending a year at Cambridge University, England.

JOHN J. KELLY, JR., and LEONARD BRANDT have resigned as associate professors of medicine at the State University of New York Downstate Medical Center, Brooklyn. Kelly has been appointed director of medical education at Mercy Hospital, San Diego, Calif., and Brandt has been named physician in chief of the Jewish General Hospital and director of medical research and lecturer in medicine at Magill University, both in Montreal.

NICHOLAS A. WEIL, former chief development engineer for the M. W. Kellogg Company, has been named director of mechanical engineering research at the Armour Research Foundation of Illinois Institute of Technology, Chicago.

JOHN H. BUCKINGHAM, professor of physical chemistry at Miami University, Oxford, Ohio, has been appointed chairman of the university's department of chemistry.

A research advisory committee composed of distinguished scientists from three universities has been named by Westinghouse Electric Corporation. Members of the committee are CYRIL S. SMITH professor of metallurgy at the Institute for the Study of Metals, University of Chicago; J. A. STRATTON, president of the Massachusetts Institute of Technology, and J. C. WARNER, president of the Carnegie Institute of Technology.

Recent Deaths

WILLIAM S. BOWEN, Westfield, N.J.; 73; founder and retired director of research, Bowen Engineering Company, North Branch, N.J.; holder of 25 patients; 11 Aug.

WILLIAM W. FRANCIS, Montreal, Canada; 81; medical historian, editor, and librarian of the Osler Library at McGill University; former editor of The *International Journal of Public Health* of the League of Red Cross Societies, Geneva; 9 Aug.

NORMAN R. HAGEN, Washington, D.C.; 52; meteorologist at the U.S. Weather Bureau for 31 years and the bureau's first public information coordinator; former president of the Meteorological Telecommunications Committee of the World Meteorological Organization; 15 Aug.

GEORGE H. HART, Davis, Calif.; 75; dean emeritus of the University of California School of Veterinary Medicine, Davis; chairman of the department of animal husbandry from 1926 to 1948; 2 Aug.

WILLIAM A. HINTON, Canton, Mass.; 75; retired professor of bacteriology, immunology, and preventive medicine of the Harvard Medical School; was the first Negro to be granted a professorship at the school; developed the Hinton test for detection of syphillis; 8 Aug.

HARVEY V. MOYER, Columbus, Ohio; 65; chairman of the department of chemistry and professor of analytical chemistry at Ohio State University; president of Phi Beta Kappa and Sigma Chi in 1946–47; 5 Aug.

ETHEL E. PATTISON, East Hartford, Conn.; 69; seed analyst and former head of the International Seed Service, New York; 7 Aug.

CORNELIUS P. RHOADS, Stonington, Conn.; 61; director of the Sloan–Kettering Institute for Cancer Research and scientific director of the Memorial Center for Cancer and Allied Diseases; 14 Aug.

HARRY SPECTOR, Chicago, Ill.; 44; chief of the Nutrition Branch of the Quartermaster Food and Container Institute for the Armed Forces, Chicago; 13 Aug.

HSIEN WU, Boston, Mass.; 65; former head of the biochemistry department at the Peiping Union Medical School in China; taught at Alabama University Medical School from 1949 to 1953; codiscoverer of the Folin-Wu method of tracing termination of sugar in the blood system; 8 Aug.

Book Reviews

On War. Raymond Aron. Translated from the French by Terence Kilmartin. Doubleday, New York, 1959. Cloth, 163 pp. $3.50; paper, 143 pp. $0.95.

Raymond Aron is a brilliant French sociologist. He is also a talented publicist with a thesis, who writes less as a Frenchman than as a citizen of the West. His thesis is that as between preserving peace "by the threat of an increasingly horrible war" and minimizing unnecessary violence by distinguishing between the different types of war, "the second is right and the first fatal."

It is not as a sociologist but as a publicist that he has written this tract for the times. As Aron says, "the sociologist is neither more nor less entitled than anyone else to indulge in these hazardous but necessary speculations" to discover the other alternatives, "between peaceful discussion and mutual annihilation."

The scientist is specifically included in Aron's assertion that "no one is qualified to give a positive answer to such questions" as the discovery of "a way out of the terror stalemate." He refers at one point to "the physicists who have suddenly become aware of their responsibilities, though without acquiring a sense of history." At another, in dismissing world government as one of the alternatives between peaceful discussion and mutual annihilation, he declares that "the scientists who enjoin us to create the universal state or perish in a monstrous holocaust do not strengthen our will but drive us to despair."

The moral, then, is that no one—natural scientist, social scientist, or theologian, for that matter—can responsibly claim to derive broad policy from necessarily narrow *expertise*. When one parades his policy preferences, he should be meticulous and self-disciplined in asserting that the policies he favors are grounded in considerations into which he alone has insight. Experts' insights into political problems are necessarily partial insights; they clarify policy choice, but they do not obviate the necessity for choice. In our society the statesman and the publicist have the task of synthesizing and integrating diverse technical, political, and moral considerations; the informed public, in turn, has the task of offering discriminating support to those whose policy prescriptions, so clarified, seem to make sense. Aron is the synthesizer, the integrator, and the man "with a sense of history" (which he thinks some experts lack).

For Aron, the middle way between peaceful discussion and mutual annihilation requires the development of a functional equivalent for periodic inter-great-power, general, total war, which in our day would also be two-way thermonuclear war. He gives short shrift to world-government proposals, sees limited use for, or possibility of, disarmament by international agreement, and dismisses appeasement on the ground that it seldom appeases. What, then, is left?

What is left is traditional diplomacy to achieve moderate objectives, backed by limited war capabilities—as well as by the retaliatory capability whose single purpose is to remove the temptation to the other side to embark on thermonuclear war. Moderation in diplomacy means fewer references to "massive retaliation" and "brinkmanship" on our side, less atomic blackmail on the other. It is not "use of a certain weapon" but "desire for too grandiose a victory" that poses the threat of unlimited war. Moderation, says Aron, would have called for a halt at the 38th parallel after the successful landing at Inchon, and the world would have called it an American victory; it would not have called for abandoning Korea without a fight. Today, in the era of approximate nuclear parity, moderation is a more obvious necessity than it was at the time of the Korean war. Massive retaliation and brinkmanship scared the allies of the United States far more than it scared our opponents.

What else would Aron do differently? He would, for one thing, have the United States give atom bombs to its European allies, in order, first, by giving these countries the power to retaliate, to strengthen the atomic deterrent to an attack on Western Europe, and second, to reduce the sense of inequality among NATO members which is a strain on the alliance. (Perhaps Raymond Aron is a Frenchman after all, as well as a citizen of the West with a sense of history.) Apparently, no one else is to have the bomb, for he writes that if the "Big Two" were to impose "a condominium on mankind," that "would be good luck indeed."

There are grounds for hope today. "The global balance," he writes, "is not at the mercy of any partial or temporary disparity." The "general balance of terror" is fairly stable, since surprise is unlikely to be so effective as to preclude retaliation. A diplomatic incident, *à la* Sarajevo, is no longer enough to set off the chain reaction of the general war. In the era of thermonuclear bipolarity, neither side is eager to use its H-bombs to force a small power to stand up and be counted on its side. Guerrilla war, meanwhile, is a type of local war in which the distant great power can coerce only with the greatest of difficulty. The economic causes of war have practically disappeared. Aron might have added that the strategic advantage to be gained by territorial expansion and the acquisition of a defensive glacis has practically disappeared too.

There are grounds for fear, too. Immoderate diplomacy, the acceptance of "war-as-destiny," the belief that all is lost unless world government is established, another psychopath at the head of one of the perhaps inevitably increasing number of atom-bomb-possessing powers—all these are real dangers. They cannot, he believes, be absolutely eliminated; they can be minimized.

WILLIAM T. R. FOX
Institute of War and Peace Studies, Columbia University

Birth Control and Catholic Doctrine. Alvah W. Sulloway. Beacon Press, Boston, Mass., 1959. xxiii + 257 pp. $3.95.

This is a challenging book, written by a Harvard-trained attorney, with an interesting preface by Aldous Huxley. Huxley points out the importance of the book and calls attention to the world-wide problem of overpopulation. He notes that uncontrolled fertility threatens thousands of millions of persons, now on earth and unborn, with

the loss of liberty and human dignity and with famine, pestilence, war, and enslavement. He believes that time is against us and that the longer we wait the harder it will be to save ourselves from biological, social, and individual disaster.

The author examines the background of the Catholic Church's position in regard to birth control. His thesis is prepared with the documented care that goes into the preparation of a careful legal brief. He shows how the laws against contraceptives evolved during the period of Victorian preoccupation with obscenity, only to be adopted by the Catholic Church 50 years later as its first line of defense against the birth-control movement initiated by Margaret Sanger and her small band of women coworkers, in 1914. Catholic authors attacked contraceptives as harmful morally, medically, economically, and socially and attributed these dire consequences to the separation of intercourse and parenthood. However, the advent of physiologic means of child spacing, exemplified by the rhythm method, and the acceptance of this method by the church strike at the heart of the arguments advanced against the use of contraceptives. The author concludes that the church has made a philosophical mistake in contending that natural law forbids the use of contraceptives and that it has been inconsistent in approving birth control by physiologic means but disapproving artificial measures. If a couple intends in good faith to have children and does have them, the primary procreative function has been fulfilled, regardless of the method of birth control practiced in the interim. The author hopes that the church, legislating for Eternity, will reappraise its present view in the interests of all mankind.

This scholarly contribution can be read with interest by all thinking people.

M. Edward Davis
Department of Obstetrics and Gynecology, University of Chicago

The State of Israel. L. F. Rushbrook Williams. Macmillan, New York, 1957. 229 pp. Plates. $4.50.

Of the many works that appeared around the tenth anniversary of the establishment of the state of Israel, Williams' *State of Israel* is probably the most useful as a general introduction for the reader unfamiliar with the subject matter. The author gives a very brief summary of the history of the Zionist movement, goes quickly over the Arab-Israeli conflict, and then discusses at length the problems of absorption of the "ingathered" immigrants, the return to the land, the welfare state, internal politics, and, finally, the relationships both with Israel's Arab minority and with the surrounding Arab states.

Williams acknowledges his indebtedness to the authorities in Israel for help in preparing the book, and the treatment of Israel is sympathetic throughout. But this approach does not always serve him well in his attempt to convey a realization of Israel's problems and of the efforts that are being made to solve them. In his chapter "Europe in Asia," the tone is set by his finding of "an efficient precision about everything" in contrast to the other new Asian states that he has recently visited. The contrast is, in my opinion, invidious. One of the reasons some Asian and African states are turning to Israel for technical assistance is that the latter represents a sort of halfway house between their own lack of development and the highly developed European and North American economies. Israel has been, and still is, engaged in solving the very same problems that confront these other states, and its experience is useful. One of the central issues is the productivity of the individual worker in industry. This has been a considerable headache to the Israeli planners, and the problem has by no means been solved. While, in the last year, the productivity of the Israeli worker increased by approximately 5 percent, the index is still well below that for the Western European worker.

The chapter "Back to the land" is not really indicative of the current scene in Israel. A disproportionate amount of space is devoted to agriculture. This is the longest chapter of the book, and it has a curiously old-fashioned flavor, as if it had been written in the 1930's instead of in this decade. The real problems in agriculture are not whether Israelis are attached to the land and are good farmers—that was proved so conclusively so long ago that it is beside the point—but, rather, whether the *kind* of farming that is being done is best for Israel's economy, and whether the proportion of people on the land may not actually already be too high. Israel is not alone in this latter respect. The United States, Egypt, and the U.S.S.R. all face the same question, to name only three. The other side of the coin—the industrialization of the state—is dealt with by Williams in rather summary fashion. Yet it is exactly here that Israel must make its greatest strides if it is to free itself from the need for perpetual subsidy.

On the question of Israel's Arab minority, Williams states that all is for the best. This is hardly borne out by the facts. Even Ben-Gurion, who recently visited Arab villages, has promised some amelioration of, though not an end to, the military administration of Arab-populated areas.

Twenty-seven excellent photographs illustrate the text.

William Sands
Middle East Institute, Washington, D.C.

Russian for the Scientist. John Turkevich and Ludmilla B. Turkevich. Van Nostrand, Princeton, N.J., 1959. ix + 255 pp. $5.95.

The appearance of this text is a propitious and timely event for Anglo-American scientists and teachers of Russian. With the important exception of James W. Perry's *Scientific Russian* previous "scientific Russian" manuals have merely provided succinct outlines of grammar, apparently on the assumption that scientific Russian is much easier for a scientist reading in his field than for the layman, and that scientists are so superior intellectually that they can bypass the ordinary plodding methods of other people in learning Russian. While it cannot be denied that the study of scientific Russian, in comparison with the study of general Russian, can be greatly streamlined, the average scientist will need a good deal of careful and patient pedagogical help before he will be able to read Russian texts with any degree of competence or facility. In my opinion, *Russian for the Scientist* provides such help, amply and expertly. At the same time, it greatly simplifies the study of Russian for those who, for understandable reasons, wish to concentrate their efforts on learning to read scientific texts, at the expense of other aspects of Russian.

Basically, this grammar approaches the problem in somewhat the same fashion as do certain contemporary regular Russian grammars. For example, it presents the cases of nouns one at a time and, in general, attempts (successfully, I think) to introduce other grammatical categories in proper pedagogical sequence. At the same time, there is a

good deal of justifiable telescoping—for example, in the simultaneous presentation of the singular and plural of the cases. The explanations of grammar are usually clear and well illustrated, and they are often accompanied by some valuable original comments. There is an abundance of exercise material, and it appears to be adequate. As would be expected, the vocabulary is scientific from the outset, an especially good selection having been made in the way of introductory material. Mention should be made of the final chapter, devoted to wordbuilding.

The readings are possibly the outstanding feature of this book. Beginning with lesson 7, each lesson includes readings (with individual vocabularies) in four fields: aeronautical engineering, biology, chemistry, and physics. These readings have been drawn, with excellent judgment, from Soviet sources, and they should prove invaluable in helping students to acquire a basic vocabulary in these fields. I consider these readings attractive enough to warrant the use of this text as a supplementary "scientific reader" for students taking a traditional course in general Russian. The use of these readings in the classroom may present something of a problem for some teachers. I myself would prefer to work out some elementary readings in various scientific fields for classroom use; this would allow me to assign the textbook readings as outside reading, to each student according to his specialty or choice.

Incidentally, the conscientious student, studying by himself, should find this manual extremely helpful. The grammar by Perry will also be useful to such students, though I think they will find the Turkevich grammar less formidable and probably more attractive.

If I were editing a second edition, I should make some minor changes, some of them deletions. I would omit the grammatical introduction completely and incorporate that material in the text; I question the value of introducing such material before the course is begun. Likewise I should prefer to see the paradigms on pages 19 and 26 omitted or, in any case, placed farther along; students who wish to see the complete paradigms in advance can consult the appendix. I feel the same way about the "Tense and aspect review" on pages 128–31; this includes forms that have not been treated at that point. It is misleading to describe the accusative as expressing duration of time for an action begun (page 28); actually, the accusative can express duration in the past, present, or future. Many students will find it difficult to understand why **избега́ть** is a "negative verb"; it would be much better to omit it. On page 39 an example (such as **спа́льня, спа́лен**) should be given for a nominative in **-я** with an inserted **-е-** in the genitive plural. On page 87 the prepositional singular of the type noun **крите́рий** has been omitted. It is misleading to describe the perfective as the "tense of narration" (page 112); the imperfective aspect may also be used for narration. On page 136 the abbreviation **кпд** is not explained; it stands, of course, for **коэффицие́нт поле́зного де́йствия.** On page 141, line 3 should read, "if the *stem* ends in a vowel." On page 144 the description of relative and interrogative pronouns as identical should be carefully limited to **кто** and **что.** On page 178 it would be helpful to give an example of the use of **бо́льше всего́.** On page 227, a more important meaning of **занима́ть** is "to occupy," and on page 228, **относи́ться** means "to refer *to,* to concern."

These are the misprints I found: On page 7 **ученой** should be substituted for **ученной** and **заранее** for **заранье.** On page 52, read **окисле́ние** for **окисле́не.** On page 57 the bottom line should read **"-ь** becomes **-ью** in both columns." On page 143, read **объясняйте** for **бъясняйте.** On page 161, read **сильно** for **сильпо.** On page 299, change **прикле́йть** to **прикле́ить.**

There is a pressing need to teach as many of our scientists as possible to read Russian, the sooner the better. That is one of the reasons why I feel that we are indebted to John and Ludmilla Turkevich for this excellent and important contribution.

NORMAN HENLEY
Johns Hopkins University and
Goucher College

Taschenbuch der Botanik. vols. 1 and 2. Walter Mevius. Thieme, Stuttgart, Germany (order from Intercontinental Medical Book Corp., New York). vol. 1, 1959, 291 pp., $3.05; vol. 2, 1958, 195 pp., $3.60.

The first volume of the two "pocket books of botany" (actually they are much larger than the title indicates) deals with plant physiology, in a thoroughly up-to-date manner. It includes reproductions of structural formulas of organic compounds and discussions of the physical chemistry of intricate life processes. The reader will be amazed to see, from this book, what an extensive background in the physical sciences is required of students of botany in Germany.

The second volume, *Plant Taxonomy,* condenses into 188 pages a large amount of material, including numerous drawings. The material, naturally, has to be tightly packed, and the volume is therefore more suitable for use as a reference manual than as a textbook.

FRANCIS JOSEPH WEISS
Arlington, Virginia

The Far East. A modern history. Nathaniel Peffer. University of Michigan Press, Ann Arbor, 1959. xviii + 489 pp. $7.50.

Nathaniel Peffer, professor of international relations at Columbia University, has devoted a good share of a scholarly lifetime to the Far East. His book is a skillfully fashioned, well-written, intelligent guide to the background of China, Japan, and their neighbors.

He sees China and Japan—particularly China—as the core of the Far East. He does his best to follow the mainstreams of historical development, without diversions or inconsequential details. His book is not for the student cramming facts for an examination but for discerning readers who want to know and to understand how the contemporary situation in East Asia came to be as complex and complicated as it is.

Peffer gives the impression that he thinks while he writes. His is no dry chronicle. He has no pet theories to pawn, no prophecies to offer. His insight comes from hard work and careful study. He does not shy away from personal judgments. His views may arouse sharp disagreement, but they will always command respect.

His story is that of the intrusion of western traders, missionaries, soldiers, sailors, and diplomats into the ancient but changing East. He sketches the intricate patterns of the social fabric of traditional China and Japan and traces with infinite finesse the colorful but imperfect designs which emerged (and are emerging) from a century of blending of East and West. The West had its historical moment of supremacy, only to recede in the backwash of World War II.

As premises for his provocative conclusions, Peffer makes some interesting suggestions about the importance of China (page 7), the spiritual health of

the Japanese people (page 31), the role of the Russians and communism in 20th-century China (page 294), the influence of Sun Yat-sen (page 306), the Communist victory in postwar China (page 443), and the stature of Chiang Kai-shek (page 444).

He believes the East "yielded, recovered, and has now found its feet again, though it must grope slowly and painfully for new paths of life. Whether it finds them, and how and with what consequences both to itself and the outer world, will determine the shape of the history of the next hundred years" (page 482).

CLAUDE A. BUSS
Department of History,
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Researches in Geochemistry. Philip H. Abelson, Ed. Wiley, New York; Chapman and Hall, London, 1959. x + 511 pp. Illus. $11.

This impressive volume on various aspects of modern geochemical research presents 23 short essays that are the outgrowth of a series of seminars held at the Geophysical Laboratory of the Carnegie Institution of Washington and at the Johns Hopkins University. Philip H. Abelson (director of the Geophysical Laboratory), editor as well as contributor, has done an excellent job of bringing together in one volume some of the recent developments in the field of geochemistry. It would be presumptuous for one person to attempt to evaluate each contribution, for these essays cover a broad spectrum in the fields of chemistry and physics applied to geology. I will, therefore, mention briefly the subjects discussed and offer some general comments on the volume as a whole.

Geochronology of crystalline rocks based on the lead-uranium, rubidium-strontium, and potassium-argon methods is reviewed by Tilton and Davis. Methods and evaluation of C^{14} age determinations are given by de Vries. Reed discusses the techniques and application of activation analysis, with special emphasis on the U-Pb-Th-He abundances to explain the age discrepancies found for meteorites. Libby reports that the short half-life of the tritium produced in atomic bomb tests can be used to determine water balance and cycles in the atmosphere and ground water. Two additional review papers within the field of nuclear geology clearly show that isotope ratios in naturally occurring materials can be used to estimate temperatures of mineral formation and degree of chemical equilibria and, in some cases, may suggest genesis of certain mineral deposits. Epstein discusses O^{18}/O^{16} variations as applied to thermometry and chemical equilibria, and Ault reviews the present data on S^{32}/S^{34} to show that fractionation can be directly tied to certain geological processes.

Two papers discuss theoretical limitations of the chemical environment during formation of ore deposits as related to the physical chemistry of the ore fluids. These are papers on magmatic gas phase, by Krauskopf, and on chemical environment of low temperature ore transport, by Barton. Thompson gives further theoretical treatment to metasomatic processes and proposes application of the phase rule to this problem by assuming local equilibrium. The often overlooked problem of reaction rates and metastability in low-temperature and low-pressure environments is summarized by Garrels.

Arrhenius discusses the source and history of pelagic sediments deposited on the ocean floor within the last 10,000 years. Keith and Degens illustrate the possibility of distinguishing between ancient marine and fresh-water sediments by use of trace-element ratios. The chemistry of the evolution of petroleum is treated by Hanson, and Abelson summarizes his recent researches on the stability of organic compounds during geological time.

Reports on laboratory studies on synthesis of selected mineral groups play an important part in this book. Kullerud's work on sulfide systems illustrates the rapid strides taken in understanding the physical-chemical relationships between the common sulfide minerals of ore deposits. Experimental studies of carbonate systems are reported by Goldsmith. Boyd has overcome the difficult problem of hydrothermal synthesis of amphiboles, and his studies shed light on the pressure-temperature conditions of the amphibolite facies. Eugster's work on hydrothermal synthesis of ferrous-ferric silicates illustrates the importance of reduction and oxidation in certain metamorphic facies. The effectiveness of combining detailed mineralogical work with phase studies on specific geological problems is demonstrated in the paper by Milton and Eugster on mineral assemblages of the Green River formation.

MacDonald reviews the current concepts of the earth's chemical composition as deduced from seismic data, the abundance of the elements within the earth's crust, meteorites, and the surface of the sun. He suggests that the earth has a composition similar to that of chondritic meteorites, with an iron-silicon core and a chemically differentiated mantle whose composition lies between that of dunite and that of basalt. The role of high pressure on chemical equilibria and transitions to denser polymorphs below the earth's crust is discussed by Clark. Hawkes' essay on geochemical prospecting describes the practical application of geochemistry to the solution of geological problems. Chayes presents experimental evidence on diffraction effects of short-range ordering in layered sequences which may be a serious problem in determining temperature-dependent order-disorder changes in the subsolidus regions of silicate systems by x-ray diffraction techniques.

These short articles average about 21 pages each and contain a total of 859 cited references. Unfortunately, there is neither an index nor a summary. The editing of this book is outstanding; I was unable to find any serious errors or omissions. Abelson's efforts to compile this excellent collection of papers will be welcomed by workers in the field of geochemistry and by geologists who find it difficult to maintain contact with this modern research. An interesting aspect of this book is the emphasis placed on nuclear geology and thermodynamics by scientists in this country as compared to the Fennoscandian and Russian approaches, wherein geochemical research is concerned mainly with the distribution and abundance of elements in nature. This trend in the United States is undoubtedly related to the rapid advances made in instrumentation as a result of basic research in physics and chemistry.

Abelson begins the preface by stating, "A major revolution in research activity in earth science has been going on for the past decade." This revolution has left the geologist a little breathless and somewhat dismayed, but the papers comprising this volume constitute a tremendous stimulation and challenge. These great advances in geochemistry and geophysics now make it necessary for the geologist to close the widening gap between concepts derived from laboratory research and theoretical analysis and the application of these concepts to field problems. These advances point clearly to the great need for more detailed information on the mineralogy and petrol-

ogy of sedimentary, igneous, and metamorphic rocks to supplement the theoretical and experimental findings. Further experimental work in the fields covered by the book demands a detailed geological framework to test conclusions and to provide guidelines.

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Introduction to Human Anatomy. Carl C. Francis. Mosby, St. Louis, ed. 3, 1959. 548 pp. Illus. + plates, $5.75.

This is a textbook on human gross anatomy. The material is divided into five units. The first, "The body and body tissues," contains chapters on the body as a whole, surface anatomy, and cells and tissues. The skeleton, joints, and muscles constitute the second unit, "Posture and movement." Unit three, "Integrative mechanisms," is devoted to the nervous system, special sense organs, and the endocrine system. "Maintenance of the body tissues," unit four, is the most extensive; it covers the circulatory, lymphatic, respiratory, digestive and urinary systems, plus the skin and subcutaneous tissues. The fifth unit, "Reproduction," is a discussion of the male and female reproductive systems. There is a glossary of anatomical terms, but the anatomical position is not defined in either the glossary or the text. The Basle Nomina Anatomica terminology is used almost entirely instead of the new anatomical terminology (Nomina Anatomica Parisiensia) adopted in Paris in 1955.

The book is well illustrated with black and white as well as colored figures, many of them drawn from actual specimens. Some of the statements are not strictly true—such as that the specific sex features in the skeleton are confined to the bony pelvis (page 113); that a healthy adult lung completely fills the pleural cavity (page 385); and that most of the abdominal organs are completely clothed by peritoneum (page 410). The descriptions given of the endocrine function of the liver (page 42) and of the pineal body (page 302) are perhaps not wholly accurate. However, these are small points, and the book should be a useful text for teaching human anatomy to nonmedical students.

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Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Anthropology in the Armed Services: Research in Environment, Physique, and Social Organization. Papers read at the annual meeting of the Society for Applied Anthropology, Syracuse University, 3 April 1958. Louis Dupree, Ed. Social Science Research Center, Pennsylvania State Univ., University Park, 1959. 53 pp.

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Reports

Fossil Canis from the Tar Pits of La Brea, Peru

Abstract. New fossil material has been obtained from La Brea, Peru. Included in this material are remains of a large wolflike canid which could not be referred to any living or fossil South American canine genus. Comparison with fossil canids from Rancho La Brea, Calif., shows that it closely resembles *Canis* (*Aenocyon*) *dirus* Leidy.

During January and February 1958, an expedition from the division of zoology and palaeontology of the Royal Ontario Museum, Toronto, excavated some tar pits at La Brea, which lies about 30 miles southeast of Talara, Peru. The deposit resembled that at Rancho La Brea, Calif. It was a matrix of sand consolidated by impregnation with asphalt. Within the matrix were found remains of invertebrates and vertebrates, pieces of wood, remains of various plants, and a few stones. The vertebrate fauna from the La Brea tar pits had a Pleistocene aspect. Remains of various animals were present; these are given here with tentative identification only (*1*): mastodon (*Haplomastodon* [*Aleamastodon*]); giant ground sloth (*Eremotherium, Glossotherium, Scelidotherium*); sabretooth cat (*Smilodon*); giant jaguar (*Felis atrox?*), horse (*Equus* [*Amerhippus*]); llama (*Palaeolama*); dire wolf (*Canis* [*Aenocyon*] *dirus*); field fox (*Dusicyon* [*Lycalopex*]) glyptodon (*Chlamytherium*); deer (*Odocoileus?*); rodent (two forms, one mouse-size and one rat-size); various unidentified aquatic and carnivorous birds; two unidentified forms of chelonian; and one unidentified crocodilian.

An examination of the material developed from the matrix during the first 6 months and referable to the Canidae shows that there were at least two canids present—namely, a large wolflike form and a small foxlike form. The latter is comparatively rare, but seems to resemble *Dusicyon* (*Lycalopex*) in its cranial characteristics. The wolflike creature is well represented, there being at present four brain cases, a badly damaged skull, many mandibles in different degrees of completeness, one femur, three tibiae, five humeri, and two atlases in good condition, together with more or less fragmentary specimens of most of the other postcranial bones. All this material is stored in the Royal Ontario Museum.

This wolflike creature was a massive animal with a marked sagittal crest projecting posteriorly from the lambdoid area, an expanded nuchal crest, flattened and uninflated frontals, well developed carnassials, and wide zygomatic arches. The rostrum is relatively long, as is the mandible. The teeth are well spaced, with little or no overlapping or contact between premolars; there are heavy and deeply implanted incisors and heavy molars. The coronoid process of the mandible is well developed, no doubt as a result of the action of the same enlarged muscles which produced the development of the sagittal and nuchal crests. Likewise, the postcranial skeleton is massive, being slightly smaller than that of a timber wolf, but relatively heavier. The Peruvian wolf was a heavier animal than any of the living canids of South America and had different proportions.

When the fossil specimens were compared with the figures and measurements for *Canis nehringi* Amegh. and *Canis gezi Krag.* (*2*), and for *Canis dirus* Leidy and *Canis milleri* Merriam (*3*), it was seen that the Peruvian form was closer to *C. dirus* than to any of the other three species. In Table 1 a comparison of selected measurements for all four species and for various specimens of the Peruvian form are given.

The figures in Table 1 for the Peruvian material fall, in all cases but one, nearer to those for *Canis dirus* than to any of the others; in the one exceptional case the figure is closest to that for *C. milleri.* It is, therefore, evident that the Peruvian wolf is not closely related to the two fossil dogs described by Kraglievich and Ameghino, and that it does not really resemble *C. milleri,* as the single dimension in which it is similar to *C. milleri* is insignificant when the other nine characters are taken into consideration.

The Peruvian wolf and *C. dirus* resemble one another in proportions, general curvature of the posteriorly projecting lamboid, width of the zygomotic

Table 1. Selected comparative measurements of *Canis gezi, C. nehringi, C. milleri, C. dirus,* and the fossil Peruvian canid from La Brea, Peru. Numbers in italics are specimen numbers and apply to all measurements listed below them.

Dimensions (mm)	*C. gezi*	*C. nehringi*	*C. milleri*	*C. dirus* Large	*C. dirus* Medium	Peruvian fossil material deposited at the Royal Ontario Museum, Toronto		
	*5120**	*500**	*11257*†	*10856*‡	*10834*‡	*2053*§		
Condylobasal length	243	236	223	282	267	271.3		
Width of rostrum above roots of C^1	54	52	50.2	67.3	58.5	57.2		
Bizygomatic width		151		175¶	164.5	160¶		
Width across postorbital processes	71¶	75	64	93.6	77.0	80.6		
						2001§	*2009*§	*2047*§
Length of mandible		165	178	230	210.5	188.3	187.8	194.9
Height of mandible at coronoid		70.5	82.5	91.3	87.0	82.2		83.4
Depth of mandible below hypoconid of M_1	32	29	29.8	39.7	37.0		36.2	39.7
	6297#					*2044*§		
Length of femur	227			260.0**	241.8††	256.8		
						2017§	*2045*§	*2046*§
Length of tibia	227	219		237**	231.6††	247.3	250.5	238.5
						2040§	*2041*§	*2042*§
Length of humerus				240**	217.9††	249.3	242.7	233.7
							2057§	*2058*§
Width across wings of atlas	97.5			120.5**			110.4	112¶

* Specimens in the Museo Nacional, Argentina. † Specimen in the University of California collections in vertebrate palaeontology (*3*). ‡ Specimens of *C. dirus* from Rancho La Brea, after Merriam (*3*). § Peruvian fossil specimens in the Royal Ontario Museum, Toronto. ¶ Approximate measurements. # Measurements of *Canis* sp. in the Museo Nacional, Argentina, after Kraglievich (*2*). ** Measurements of various *C. dirus* limb bones after Merriam (*3*). †† Means of various measurements of limb bones of *C. dirus* after Stock and Lance (*4*).

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

arches, and massiveness of the dentition. In no character was there a wide divergence between these two animals. On the other hand, the Peruvian fossil differs from the illustrations of *C. gezi* and *C. nehringi* in the shape of the dorsal profile of the skull. In *C. gezi* and *C. nehringi* the frontals are inflated, as in many domestic breeds of dog. None of the La Brea specimens from Peru show this inflation. The rostrum is shorter and lighter in both *C. gezi* and *C. nehringi* than in *C. dirus* and is so constructed the P^4 seems to be set below and behind P^3 to give the suggestion of a "step down" from P^3 to P^4. This condition is not clearly marked in *C. dirus*.

Comparison of the postcranial skeleton of *C. dirus* and that of the Peruvian fossil canid shows a striking similarity both in shape and dimensions, while the postcranial material of both *C. gezi* and *C. nehringi* is so scarce that little comparison is possible.

The conclusion resulting from this first investigation is that a large wolf-like creature existed in the Pleistocene of Peru and that this creature belongs within the genus *Canis* and is closely related to *C. dirus* of the Californian Pleistocene tar pits. Until further material has been developed from the matrix it is too early to state definitely whether it is identical with *C. dirus* or not, and it is proposed for the present to refrain from giving the Peruvian wolf a separate name, since its synonymity with *C. dirus* is a distinct possibility.

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24 February 1959

Effect of Anxiety on the Akerfeldt Test

Abstract. Acute anxiety episodes do not significantly alter the lag time of the Akerfeldt test, serum ceruloplasmin level, or serum ascorbic acid level in man.

Ostfeld, Abood, and Marcus have recently reported that the concentration of ceruloplasmin in the serum of "disturbed" patients is significantly greater than the levels found in more "tranquil" patients (*1*). The primary behavioral characteristic of the disturbed patients which differentiated them from the less disturbed group was their greater degree of anxiety. We have attempted to verify this claim by experimentally raising the anxiety level under hypnosis of a group of normal volunteers and measuring their ceruloplasmin level (along with several related biochemical variables) before, during, and after the experimental anxiety state. A detailed description of the experimental subjects and the mode of their selection, the experimental design employed, the method of producing the experimental anxiety state during the hypnotic trance, and of the anxiety state achieved, has been reported elsewhere (*2*).

Table 1. Lag times and slopes of Akerfeldt tests and serum ascorbic acid levels of 12 normal subjects on four different occasions. (Means ± standard deviations for six male and six female subjects.)

Occasion	Assay					
	Lag time (sec)		Slope (ΔO.D./sec)		Ascorbic acid (mg/100 ml)	
	M	F	M	F	M	F
Pre-hypnosis	167 ± 162	318 ± 118	8.2 ± 3.1	11.2 ± 3.5	1.39 ± 0.97	2.70 ± 0.70
Hypnosis	163 ± 161	317 ± 153	7.9 ± 2.9	11.6 ± 3.2	1.24 ± 0.88	2.53 ± 0.67
Hypnosis + anxiety	163 ± 156	285 ± 79	8.7 ± 2.3	11.5 ± 3.4	1.28 ± 0.76	2.67 ± 0.66
Post-hypnosis	167 ± 162	302 ± 129	10.4 ± 7.4	12.6 ± 4.1	1.29 ± 0.72	2.60 ± 0.48

Table 2. Analysis of variance among the lag times, slopes, and ascorbic acid levels by sexes and occasions.

Variation	df	Lag time		Slope		Ascorbic acid	
		MSq.	F	MSq.	F	MSq.	F
Between sexes	1	236,602	2.97	100.34	2.98	21.081	10.44*
Between subjects in sexes	10	79,722		33.63		2.020	
Between occasions	3	796	1.19	8.83	0.82	0.054	0.86
Between occasions × sexes	3	743	1.11	1.23	0.12	0.005	0.08
Between occasions × subjects in sexes	30	668		10.71		0.062	
Total	47						

* Significant at better than the 5 percent level.

Blood samples were drawn from each subject on four occasions: (i) before hypnosis, (ii) during hypnosis, (iii) during the hypnotically induced anxiety state, and (iv) after hypnosis. Serum obtained from these samples was analyzed immediately for the delay in oxidation of N,N-dimethyl-*p*-phenylenediamine (lag time of Akerfeldt test) (*3*), the slope of the oxidation curve, and the concentration of ascorbic acid in the serum. The lag time and slope were measured as follows: 1.5 ml of 0.1 percent N,N-dimethyl-*p*-phenylenediamine dihydrochloride was added to 1.5 ml of serum, and the optical density at 552 mμ was determined in a Beckman DU spectrophotometer at 10-second intervals until oxidation of the substrate was complete. Serum and water (1.5 ml each) were employed as the blank. The lag time was taken as the time in seconds before oxidation of the substrate commenced and was obtained graphically from the intersection of the two rate curves of the over-all reaction. As the index of ceruloplasmin concentration, the average slope of the substrate oxidation curve was chosen (change in optical density per second). Serum ascorbic acid was determined by the method of Mindlin and Butler (*4*). Aprison and Grosz (*5*) have shown that the lag time is proportional to the ascorbic acid content of the serum.

The results of our experiment are given in Table 1. An analysis of variance for each variable by sex and occasion is given in Table 2. The female subjects exhibited a longer lag time, a greater slope, and a larger ascorbic acid level on each experimental occasion, but this tendency was significant only for the level of ascorbic acid. Although the lag time for females is almost double that for males, the enormous variability of individual response prevents this difference from attaining the conventional 5 percent confidence level. The female subjects also manifest higher ceruloplasmin levels on every testing occasion, but here again statistical significance is not achieved. The greater ascorbic acid level of the female subjects is most likely due to the much greater ascorbic acid intake by these subjects. The elevated ascorbic

acid levels of the female subjects are responsible for the longer lag times of these same individuals.

The effects of the various experimental manipulations on each variable measured are not significant. Despite a considerable increase in anxiety during the hypnosis plus anxiety occasion, the ceruloplasmin level did not change significantly. The anxiety levels achieved resembled those seen in severely disturbed, hospitalized psychiatric patients. Plasma hydrocortisone levels determined on aliquots of the blood samples drawn from the female subjects in this study were 75 percent higher during the anxiety occasion than during the hypnosis occasion (*2*).

The differences in conclusions between Ostfeld and his co-workers and ourselves concerning the effect of anxiety on serum ceruloplasmin level is not presently clear. They may reflect fundamental differences in the kind of anxiety studied, in the assessment of anxiety, or perhaps in differential effects resulting from chronic as contrasted with acute anxiety.

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27 April 1959

Hybridization of Salmonella Species by Mating with Escherichia coli

Abstract. A number of species of *Salmonella* were fertile at low frequency as recipients in crosses with *Escherichia coli,* as evidenced by the isolation of lactose-positive hybrids possessing the *Salmonella* antigenic structure. A hybrid from an initial mating, when crossed again with *E. coli,* behaved then as a high-frequency recipient strain.

Genetic recombination in *Escherichia coli,* discovered by Tatum and Lederberg (*1*), and the fertility system involved in the mating between various strains of this species have been described in much detail (*2*). It is now apparent that a unilateral contribution of genetic material from the donor (Hfr, F^+) strain to the recipient (F^-, F^+) takes place. Recently, Luria and Burrous (*3*) have reported recombination between *E. coli* and many *Shigella* species which acted as F^- strains in these matings. Attempted crosses between *E. coli* and *Salmonella,* however, were unsuccessful until Baron *et al.* (*4*) detected recombination at low frequency between *E. coli* and *Salmonella typhimurium* strain TM-9. Subsequently, a streptomycin-resistant mutant of TM-9 was isolated prior to mating, and this strain (TM-9S^r-2) acted as a high-frequency recipient strain in matings with *E. coli.*

As an extension to the studies with *E. coli* K-12, Lederberg (*5*), using an appropriate screening procedure, surveyed a large number of other strains of *E. coli* for genetic recombination. In a similar study, following the initial observations with *S. typhimurium,* we have examined other species of *Salmonella* for ability to act as recipients in crosses with *E. coli* K-12, employing the following procedure.

The various *Salmonella* cultures were grown on nutrient agar plates, harvested after 18 hours' growth, and washed three times with saline. The donor culture of *E. coli* used was the strain of high frequency of recombination (Hfr) for lactose, isolated by Cavalli (*6, 7*). This culture was grown in Penassay broth, washed, and plated with each of the *Salmonella* cultures at a ratio of one Hfr (donor) cell of *E. coli* to 20 *Salmonella* (potential recipient) cells on minimal lactose agar plates. This medium would not support the growth of the parent methionine-requiring (M^-) *E. coli* Hfr cells or the parent lactose-negative (Lac^-) *Salmonella* species in control platings of the parent cultures alone, but would reveal methionine-independent lactose-positive (M^+Lac^+) progeny.

The results of this study have revealed that, in addition to the three strains of *S. typhimurium* (TM-9, LT-7, and HB) previously reported to be fertile by Baron, Carey, and Spilman (*8*), five strains of *S. typhosa,* two strains of *S. paratyphi* B, the Vi-containing East Africa strain of *S. paratyphi* C, *S. abortus-equi,* and *S. strasbourg* also gave rise to Lac^+ progeny which exhibited the antigenic characteristics of the parent *Salmonella* cultures. These strains and their antigenic structures, according to the Kauffmann-White schema (*9*), are listed in Table 1.

Table 1. *Salmonella* species yielding Lac^+ recombinants in crosses with *E. coli* Hfr.

Species	Antigenic structure	Recombination frequency	Source
S. typhimurium TM-9	4,5,12:i,1,2	4×10^{-5}	P. R. Edwards
S. typhimurium TM-9S^r-2	4,5,12:i,1,2	1×10^{-4}	From TM-9
S. typhimurium LT-7	1,4,5,12:i,1,2	1×10^{-7}	E. Englesberg
S. typhimurium HB	1,4,5,12:i,1,2	$< 10^{-8}$	Mouse
S. paratyphi B3	4,5,12:b,1,2	$< 10^{-8}$	P. R. Edwards
S. paratyphi B7	4,12:b,1,2	$< 10^{-8}$	P. R. Edwards
S. abortus-equi 26	4,12:_, enx	$< 10^{-8}$	P. R. Edwards
S. paratyphi C32	Vi 6,7:c,1,5	1×10^{-7}	P. R. Edwards
S. typhosa Ty2	Vi 9,12:d	$< 10^{-8}$	A. Felix
S. typhosa Ty2W	_9,12:d	$< 10^{-8}$	From Ty2
S. typhosa H-901	_9,12:d	$< 10^{-8}$	A. Felix
S. typhosa 0-901	_9,12:_	$< 10^{-8}$	A. Felix
S. typhosa 643	Vi 9,12:d	$< 10^{-8}$	A. Wolff
S. typhosa 643L^-	Vi 9,12:d	1×10^{-4}	From 643L^+
S. strasbourg 148	9:d,1,7	$< 10^{-8}$	P. R. Edwards

No recombinants were obtained from approximately 70 other species or strains of *Salmonella* with the same or similar serotypes, although in some instances heavy background growth, probably due to reciprocal feeding of the mixed cultures, may have obscured the results. In any case, there appears to be no evidence for any association between known antigenic components in the *Salmonella* tested and their ability to act as recipients in these crosses.

As a consequence of these and earlier experiments (*4*), it was assumed that populations of *Salmonella* cells generally are unable to act as recipients. For the sake of clarity, these cultures will be referred to as F^0 strains. At a low frequency, the F^0 cells in the population of certain or, perhaps, many species of *Salmonella* mutate to or in some manner acquire the F^- recipient state. These occasional F^- cells in the F^0 population will mate with the Hfr *E. coli.* A hybrid which is isolated from an initial mating (*E. coli* Hfr × *Salmonella*) should, according to this concept, be F^- and, hence, capable of being mated again as a recipient strain to yield hybrids at a high frequency. Recombination of such a strain should be detected also with the lower-frequency donor *E. coli* F^+ strains. The availability of a number of selective markers in *S. typhosa* strain 643 enabled us to test this possibility (*10*). A Lac^+ hybrid of strain 643 was selected for further examination, since it still possessed the antigenic and biochemical manifestations (other than

lactose utilization) typical of its parent typhoid culture (*11*).

This Lac$^+$ hybrid, referred to as strain 643L$^+$, still arabinose-negative (Ara$^-$), was again mated with the *E. coli* Hfr and also with an *E. coli* F$^+$ strain on minimal medium containing *l*-arabinose. Hybrids of the presumably F$^-$ strain 643L$^+$ appeared at a relatively high frequency in the Hfr cross and could also be detected in the F$^+$ cross, whereas the previously unmated F^0 strain 643 failed to yield any recombinants that were able to utilize *l*-arabinose.

An opportunity to determine the frequency of recombination for Lac$^+$ occurred when Lac$^-$ hybrids of 643L$^+$ were obtained from matings of this strain with a Lac$^-$ Hfr strain of *E. coli* (*12*). These Lac$^-$ hybrids, observed in the progeny of crosses selected on minimal *l*-arabinose medium, were able to recombine at a high frequency for Lac$^+$ when mated again with the Lac$^+$ *E. coli* Hfr. The frequency of recombination found here (expressed as the ratio of recombinants to the number of Hfr parent cells) was of the order of 1×10^{-4}. This is typical of the frequency determined for the streptomycin-resistant mutant of *S. typhimurium* (TM-9S^r-2), which is now considered to have been a fortuitous isolation of an F$^-$ strain from the population of F^0 cells of *S. typhimurium* TM-9 prior to mating (*13*).

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27 April 1959

Radiation-Induced Crystallization of Sucrose

Abstract. In the presence of gelatine, sucrose crystallizes after a relatively short time (minutes, hours) when exposed to the radiation of an x-ray tube with copper target, or of a medical microwave unit. The formation of sucrose spherulites, visible with the naked eye, was observed.

The crystallization of sucrose from water solutions is inhibited by various substances, such as gelatine, which both hinder the formation of crystal nuclei in supersaturated solutions and reduce the rate of crystal growth. When sweetened and fruit-flavored gelatine (Jello) is dried, the sucrose generally remains in "solid solution." If crystallization does take place, a long period of time (weeks, months, or more) elapses before it is detected. Crystallization of sugar started to take place in a dried raspberry-flavored Jello, however, shortly after it was exposed to x-rays or microwaves.

Figures 1*A* and 1*B* show the x-ray diffraction patterns of Jello before and after a relatively long exposure to x-irradiation from a tube (copper target) operated at 40 kv and 20 ma. While only two amorphous rings appear before irradiation (Fig. 1*A*), the presence of "Laue spots" in Fig. 1*B* indicates that a great number of small single crystals (approximate size, 300 μ) were formed during the 6-hour exposure. The crystals obtained were identified as sucrose by their powder pattern (*1*). Their size increased with the time of exposure.

A similar effect was observed after the dried sample was irradiated by means of a 100-watt medical microwave unit (Raytheon, $\lambda = 12.5$ cm) at a distance of approximately 5 cm. The originally transparent gelatine became opaque in a few (10 to 15) minutes, and the sucrose crystallized in spherical aggregates consisting of radially arranged needles barely visible with the naked eye (Fig. 2). The x-ray diffraction pattern of these spherulites (Fig. 1*C*), obtained with a small pinhole (100 μ di-

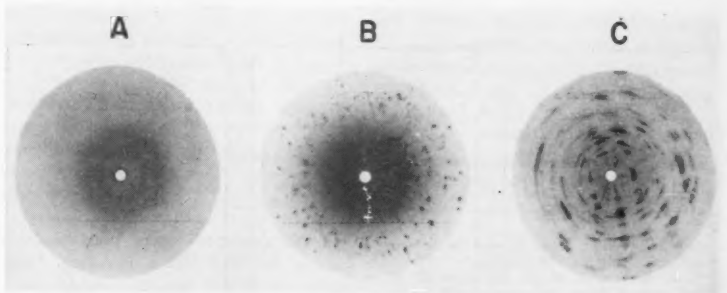

Fig. 1. X-ray diagrams. (*A*) Before irradiation; (*B*) after irradiation; (*C*) sucrose spherulite. (CuKα-irradiation; plane film; specimen-film distance, 15 mm.)

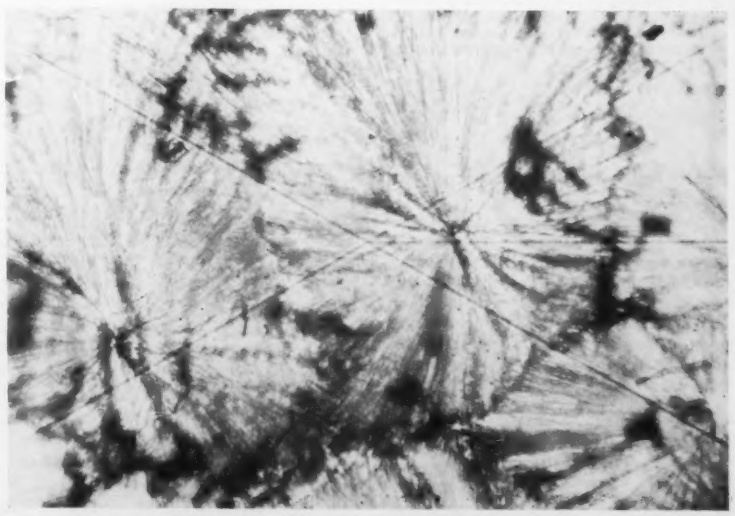

Fig. 2. Sucrose spherulites (polarized light, crossed Nicols). (About × 30)

ameter) in the Norelco micro diffraction camera, is almost identical to a rotating crystal diagram. The long dimension of crystal needles, corresponding to the "rotation axis" of the diagrams, coincides with the *b* axis of the monoclinic elementary cell of sucrose (*2*).

The observed crystallization is similar to the "recrystallization" of Al_2O_3 under the influence of ionizing radiation. According to Baskin and Semerchan (*3*), exposure to an electron beam or to hard x-rays increases the rate of crystal growth and makes the production of Al_2O_3 single crystals possible.

Although the formation of sucrose spherulites was surprising, it can be understood in view of the fact that microscopic spherulites of many substances have been observed during recent years, for instance in organic high polymers such as polyamides, polyesters, polyethylene, and rubber (*4*); spherulites of graphite have been observed in cast iron (*5*), and so on. Apparently the presence of foreign substances affecting the superficial tension of the medium from which crystallization takes place greatly influences the crystal habitus and causes the spherulitic growth of sucrose.

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27 March 1959

Photosensitive Site in Lettuce Seeds

Abstract. Red light is effective only in promoting germination of Grand Rapids lettuce seeds, and far-red light is effective only in inhibiting it, when the hypocotyl half of the seed is exposed to the light. It is concluded that the photoreceptor is probably located in the tip of the hypocotyl.

In recent years studies of the effect of light on the germination of photosensitive seeds have been focused upon the photoreversibility of the reaction between red and far-red light (*1*). The photoreceptor has been considered to be a pigment system which changes its absorbing form with red and far-red light and which may be identical with the system mediating other photoreversible reactions in plants (*2*). However, few attempts have been made to locate the actual site of the light-absorbing system in the seed. Klein and Preiss (*3*) reported that if the seeds are turned over between the illumination with red and far red, so that the two exposures are given to opposite sides, then the germination-promoting effect of the red is still reversed by the far red, and vice versa. Since very little light could be transmitted through the seed, these results raise the question of possible diffusion of the photoreceptor or of photoproducts across the seed tissue. However, these experiments did not show which morphological unit it is that reacts to the incident light. In the following paragraphs (*4*) it is shown that the light-absorbing system is present in the hypocotyl half of the seed, but not in the cotyledon half.

The seeds used were those of *Lactuca sativa* var. Grand Rapids, supplied by Breck's (Boston, Mass.). Fifty seeds were soaked in a 9-cm petri dish on two layers of black filter paper (Schleicher and Schüll No. 2490) with 5 ml of distilled water in darkness at 25°C. Since preliminary experiments had shown that a dark purple dye coming out of the filter paper inhibited the germination of the seeds considerably, the filter paper was washed thoroughly with running tap water for 24 hours beforehand. After 1.5 hours of imbibition, each seed was carefully covered with a piece of aluminum foil by means of a pair of fine forceps, under a green safe-lamp (20-watt fluorescent lamp filtered through two layers each of yellow and green cellophane), either the cotyledon half or the hypocotyl half of the seed being left uncovered. Completely covered and uncovered seeds were prepared as controls. The procedure took 20 to 25 minutes; the safe-lamp was known to produce very little effect on germination in this time. Exactly 2 hours after the beginning of imbibition, all seeds were irradiated for varying times up to 5 minutes with red light (100-watt incandescent lamp filtered through a Corning Signal Red glass filter, placed 25 cm above the level of the seeds). Similar experiments were run with seeds whose fruit coats had been removed, except that 25 seeds were used per petri dish instead of 50. Immediately after the red irradiation, the piece of aluminum foil was quickly removed from the seed, lest suppression of the respiration of the seed interfere with germination.

Table 1. Effect of 2 minutes' illumination with red or far-red light on half-exposed Grand Rapids lettuce seed. Red illumination was given at 2 hours and far-red at 3 hours following illumination with red at 2.5 hours (all times were measured from the beginning of imbibition).

Exposed part	Germination (%)				
	Normal seed: irradiation for				Seed with fruit coat off: irradiation for 2 min
	10 sec	30 sec	2 min	5 min	
	Red light				
Hypocotyl	55	89	93	88	98
Cotyledon	7	8	16	17	42
Whole seed	63	96	96	98	100
None	4	6	5	4	28
	Far-red light after red illumination of the whole seed				
Hypocotyl		14	2	1	
Cotyledon		91	74	41	
Whole seed		1	5	2	
None		92	89	93	

For experiments with far-red light, a 100-watt reflector flood lamp, with Corning glass filter No. 7-69 (2600) (50 percent transmission at 742 mμ) placed 25 cm above the level of the seeds, was used. After 2.5 hours' imbibition in the dark, all seeds were given 2 minutes' irradiation with red light, as discussed above, to induce germination. Either the cotyledon or the hypocotyl half of each seed was then covered with aluminum foil, and far-red light was given for various periods of time exactly 3 hours after the beginning of imbibition. After the light treatment the aluminum foil was quickly removed from the seed, as before.

Table 1 shows the results of the experiments, each reading being the average from two dishes. These results show that red light promotes gemination when only the hypocotyl is exposed almost as well as it does in control seeds which are wholly exposed. Similarly, far-red light inhibits germination whether the whole seed or only the hypocotyl is exposed. Exposure of the cotyledons, on the other hand, has little effect, since germination is about the same as that of

the dark control, whichever light is used. The small extent of germination following longer irradiation with red light (2 and 5 minutes), or the corresponding inhibition following longer irradiation with far red, can be explained as the effect of scattered light due to the long exposure. Seeds from which the fruit coats have been removed show essentially the same behavior as the normal seeds with fruit coats on.

A number of reports on light-sensitive seeds have indicated that the seed covering restricts germination in darkness mechanically and that its integrity determines the light sensitivity of the seed (*5–7*). In lettuce the presence of the intact endosperm layer or "seedcoat" has been shown to be necessary for the light sensitivity of the seeds (*5, 7*). This, however, does not necessarily mean that the endosperm is the light-sensitive site. Should the pigment system be in the endosperm layer, its presence must evidently be limited to the half which covers the hypocotyl, but since that is the part of the seed which elongates in germination, it seems more reasonable to conclude that the photoreceptor pigment is present in the hypocotyl itself. That the photoreceptor should be close to the extreme tip of the seed would, of course, give a simple explanation of the observation of Klein and Preiss (*3*), since this is the only part which can receive light from either direction.

It can, therefore, be concluded that the light-sensitive site is either in the seed covering at the hypocotyl end, or, more probably, in the tip of the hypocotyl itself. The hypocotyl would thus be not only the site of elongation but also the region of light sensitivity.

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Magnitude of the Moon Illusion as a Function of the Age of the Observer

Abstract. The diminution in the apparent size of an object when viewed overhead as compared with its apparent size in the horizontal plane is greater for children than for adults. This relationship, of which the well-known moon illusion is a special case, is interpreted to be a consequence of the normal development of size constancy.

The relatively small perceived size of the moon when seen in elevation as compared with its large appearance at the horizon is one of the oldest recorded visual phenomena. Since the angle subtended by the moon's disk is actually somewhat smaller at the horizon, the striking difference in its perceived size has been referred to as the "moon illusion." A number of explanations have been offered for this phenomenon (*1*). It is the purpose of this report to attempt to relate the moon illusion to normal processes of perceptual development. To this end, the magnitude of the effect was determined for adults as well as for children of various ages.

Schur (*2*) has demonstrated that the essential feature of the illusion, that is, the change in apparent size as a function of elevation, holds not only for celestial but also for terrestrial objects. She projected a spot of light on the ceiling of a large room and asked adult subjects to adjust the size of a similar spot of light, at the same viewing distance but projected on a vertical screen at eye level, to match the overhead light. Under these conditions, the disk viewed overhead appears smaller than the one viewed in the horizontal plane.

We have repeated this experiment in a darkened theater at a viewing distance of 35 feet and also outdoors by extending a disk, parallel to the ground, from the roof of a building 85 feet high. In both experiments, the subjects sat directly below the overhead disk and compared its size with that of a similar disk in the horizontal plane at the same viewing distance. The subjects observed binocularly with unrestricted head, eye, and neck movements. In every case the disk in the horizontal plane judged equal in apparent size to the overhead disk was physically smaller than the overhead disk. Nineteen adults and nineteen children ranging in age from 4 to 11 years served in the outdoor experiment. The data plotted in Fig. 1 present the matched size of the horizontal disk

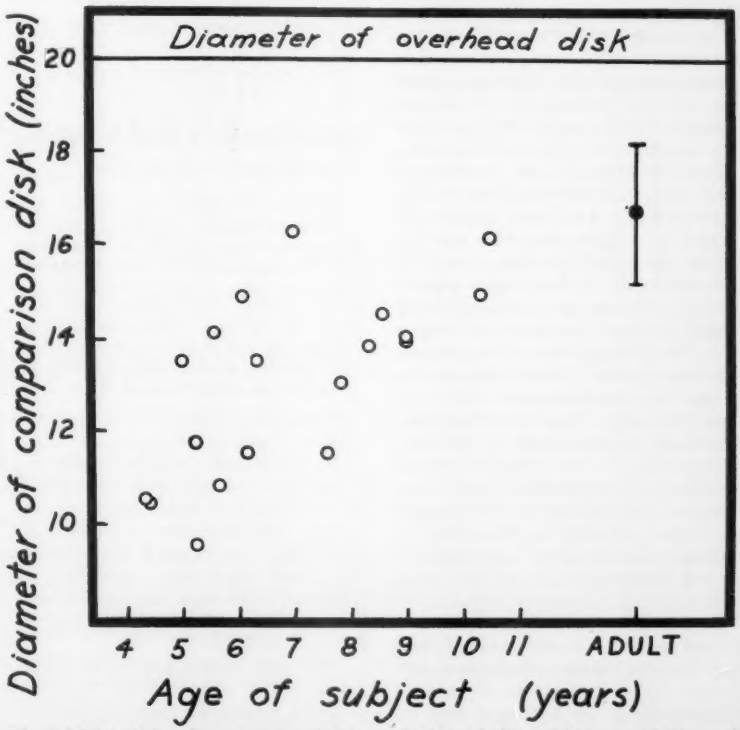

Fig. 1. Matched size of a comparison disk in the horizontal plane which was judged equal in apparent size to an overhead disk 20 inches in diameter. Open circles represent values for individual children. The mean for 19 adults, with the limits for one standard deviation, is given by the solid circle.

as a function of the age of the observer. On this plot, a correct size match would fall on the horizontal line representing 20 inches, the size of the overhead disk. It can be seen that all subjects underestimated the overhead disk and that the amount of underestimation is a function of the age of the subject. The youngest children demonstrate an underestimation of about 50 percent, this value decreasing with increasing age to about 16 percent for the adult subjects.

These data were corroborated by the indoor experiment in which 10 children and 10 adults participated. The adults underestimated the overhead disk by 19.1 percent, and the children, who ranged in age from 5 to 8 years, by 32 percent. In both experiments the data for the adults are comparable to those obtained by Schur. In addition, the effect is seen here to be related to the age of the subject, the diminution in apparent size of the overhead disk increasing with decreasing age of the observer.

It is our interpretation that these results can be related to normal perceptual processes as indeed must be the case for all illusions. Since the moon illusion is a special case of the perception of size, any explanation of this effect must be in terms of the processes which generally subserve size perception.

It is a remarkable achievement of the human visual system that the apparent size of objects tends to be perceived correctly despite extensive changes in the dimensions of the corresponding retinal image resulting from variation in viewing distance. Although the mechanisms underlying this biologically important phenomenon, referred to in the psychological literature as size "constancy," have not been completely identified (*3*), the effects are clear. Size constancy results from a "correction" such that the greater the viewing distance for an object subtending the same visual angle—that is, producing the same sized retinal image, the larger the object will appear (*4*). The ability to make this correction for objects located near to the observer is good for both adults and children so that, for a given retinal image size, perceived size is proportional to distance. However, as the observation distance is increased, this correction is no longer complete, and especially so the younger the subject. Presumably the ability to make a size correction for distantly viewed objects depends on experience (*5*).

Such results for size perception in general suggest that the moon illusion may be a consequence of the fact that human beings have more experience with objects in the horizontal than in the vertical plane, and thus make a larger size correction for an object subtending the same visual angle—for example, the moon—when viewed horizontally. Since children have less experience with distantly viewed objects, especially when viewed directly overhead, the magnitude of the moon illusion is greater the younger the observer. Thus the moon illusion is interpreted as resulting from a normal developmental process, namely the dependence of the magnitude of the size constancy correction on experience (*6*).

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Self-Regulation of Brain-Stimulating Current Intensity in the Rat

Abstract. A modification of the self-stimulation technique of Olds enabled rats to regulate and maintain at a preferred level the amount of brain-stimulating current they received as reinforcement for lever pressing. The method used two levers to deliver brief brain shocks: each response at one lever increased the current intensity a small step and each response at the other lowered it one step.

It is well established that animals will work to stimulate certain portions of the brain electrically (*1*). This self-stimulation technique has considerable promise as a tool for investigating the central nervous system actions of many variables. Olds has reported, for example, that food deprivation, castration, or drugs will selectively change the baseline rates of self-stimulation of particular brain structures (*2*).

The present report describes an elaboration of the self-stimulation technique in which animals are furnished with the means to regulate the amount of brain-stimulating current they receive as reinforcement. The new method thus permits a continuous determination of the preferred intensity of stimulation, and at the same time gives the rate of self-stimulation as before (*3*).

The animals were trained in a small, sound-resistant box with two levers in one wall. Operations of either lever delivered brief brain shocks. A two-way stepping relay provided 24 equal current steps (from 0 to approximately 50 ma, depending on the electrode impedance) by introducing appropriate resistances into the stimulating circuit. Responses at one lever drove the stepper forward, producing brain shock reinforcements of increasing intensity, and responses at the other stepped it back, decreasing the intensity. Any current level, once established, could be maintained by alternating responses between the levers.

Continuous records of the amount of current selected were drawn by a recording potentiometer whose input voltage was controlled by the two-way relay through an auxiliary bank of resistances (*4*). A cumulative response recorder and impulse counters simultaneously provided records of the self-stimulation rate.

The stimulating current was supplied from a pulse-pair generator similar to that described by Lilly *et al.* (*5*). The relatively noninjurious wave form had positive and negative peaks each 50 μsec in duration and separated by 200 μsec. A brain-shock reward consisted of a train of pulse-pairs 50 to 100 cy/sec in frequency and fixed in duration at either 0.25 or 0.5 sec; the stepper could not be reoperated until a train was delivered. Optimal values of frequency and train duration varied for different animals and were selected experimentally.

The subjects were male albino rats with bipolar electrodes (0.01-in. platinum wires, twisted together and insulated except at the tips) permanently implanted in rhinencephalic, hypothalamic, and midbrain tegmentum sites (*6*). In preliminary training, the animals practiced conventional self-stimulation—either lever gave brain shocks of a fixed, moderately reinforcing intensity. After the self-stimulation rates had stabilized, the rats were required to alternate between the levers to obtain the fixed-intensity electrical stimulus (one 2-hour session).

Training in regulating the current followed on the next day. Most animals learned readily how to control the intensity of the stimulation, and variability decreased rapidly with practice. Assistance from the experimenter early in training—for example, raising the current when it was driven down and held at zero, or lowering it when punishing or convulsive levels were approached—greatly facilitated the process.

Sample records of several consecutive hours of current regulation by two well-trained animals are shown in Fig. 1.

Five-minute periods of self-stimulation were alternated with 5-minute rest periods during which the stimulator and the box lights were turned off. Resetting the current to zero in the rest periods required the animals to recover the preferred intensity at the start of every stimulation period and provided a stringent test of regulating ability.

Current regulation may be observed to be good in both cases, although the levels selected tended to rise somewhat during the experimental sessions. Both the amount of current preferred and the width of the self-selected intensity band were stable for many weeks and, after sufficient "warm-up," even following long breaks in training (*7*).

The self-selected intensity level was always well above the reinforcing threshold; usually it was higher than most experimenters would care to assign under the conventional fixed-intensity procedure. Exaggerated and even violent motor activity was often produced by the intensities selected, and after a session of a few hours an animal generally was physically exhausted and wet with saliva.

The effect on intensity regulation of manipulating the frequency of the stimulating current for a rat with an electrode in the midbrain tegmentum is depicted in Fig. 2. Similar experiments with other animals employing a limited range of frequencies (25 to 150 cy/sec) indicate that increases in frequency lead to the selection of smaller intensities, and decreases in frequency lead to higher intensities. The fact that animals tend to compensate for frequency changes in one direction by selecting intensities in the opposite direction suggests that self-regulation is based on a preferred energy of stimulation.

Some of the neural mechanisms that may underlie current-regulating performance may be discussed briefly. Increasing the intensity of the stimulating current train has at least two important effects: (i) the probability or frequency of activation of neurons in the stimulating field is increased; and (ii) the effective stimulating field is enlarged to include new elements. On the assumption that animals will work to maximize the firing of positively reinforcing cell groups, it may be expected that, within physiological limits, the greater the current the better. That intermediate intensities are favored may be due, in part, to the spreading of stimulation with large currents to inhibitory or negatively reinforcing regions.

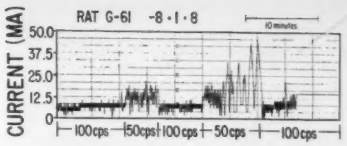

Fig. 2. Changes in the self-selected intensity level induced by manipulation of the frequency (pulse-pair repetition rate) of the stimulating wave form. The data at the end of the experiment are unreliable, owing to the physical exhaustion of the animal.

It follows from this that the amount of current selected to stimulate a positively reinforcing site will depend importantly on its proximity to negative cell groups. According to mapping studies of Olds (*2, 8*), negative reinforcing effects are localized caudally in the rat brain; hence, smaller currents should be selected to stimulate caudal rewarding sites (for example, hypothalamus and midbrain tegmentum) than rostral sites (for example, septum and cingulate cortex).

Preliminary findings suggest that this is the case. Electrodes in the region of the septum produced poor regulation—for the most part, the current was increased until convulsions occurred (*9*). Even more compelling evidence was provided by an animal (rat F-49) with both an anterior electrode in the cingulate cortex (just rostral to the septum) and a posterior electrode deep in the midbrain tegmentum. Cingulate performance consisted mainly of intensity increases to convulsion-producing levels (usually 40 to 50 ma), although at the tegmental site the animal self-regulated expertly (*10*).

It is anticipated that the self-regulation technique will be useful in a variety of situations. Some data have been collected already on the effects of drugs; and to suggest one other example, it seems feasible, by stimulating other brain sites during self-regulation in a particular structure, to obtain information concerning relations of facilitation and inhibition between central structures.

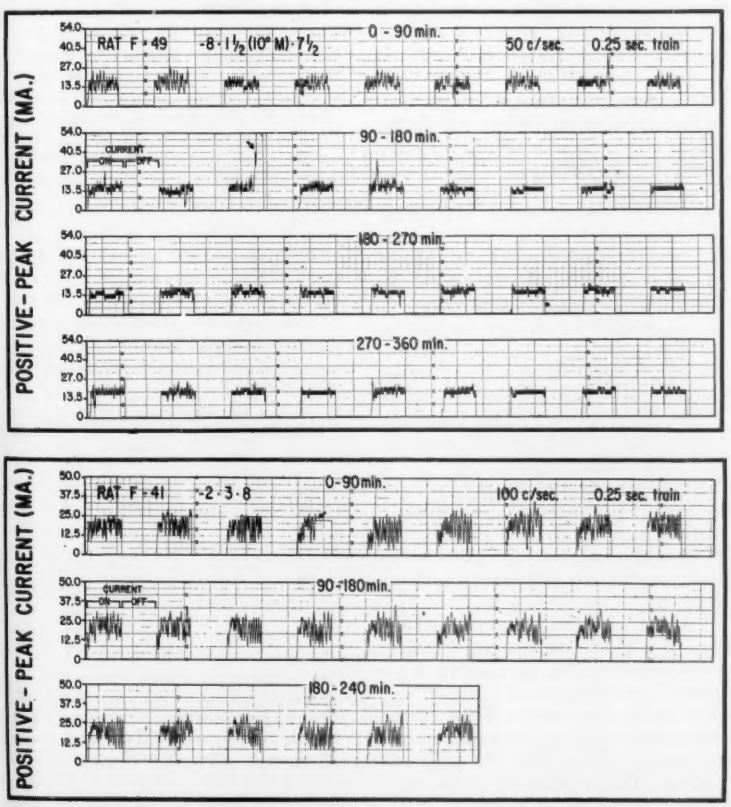

Fig. 1. Current intensities selected throughout an experimental session by two well-trained rats. (Top) Graph for rat F-49, with electrode in midbrain tegmentum. In the 90- to 180-min segment of the graph, the arrow marks an example of the current-maximizing behavior described in (*7*). (Bottom) Graph for rat F-41, with electrode in the lateral hypothalamus. The arrow in the 0- to 90-min segment of the graph indicates a period of no response during which the stimulating leads were untangled. The self-stimulation rates were quite constant throughout the sessions and averaged 34 per minute for rat F-49 and 42 per minute for rat F-41.

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1. J. Olds and P. Milner, *J. Comp. Physiol. Psychol.* 47, 419 (1954).
2. J. Olds, *Science* 127, 315 (1958).
3. Similar utilizations of operant conditioning techniques have been reported by Blough for determining visual thresholds in the pigeon and by Weiss and Laties for measuring tolerance of pain in the rat: D. S. Blough, *Science* 121, 703 (1955); B. Weiss and V. G. Laties, *ibid.* 128, 1575 (1958).

4. Appreciation is expressed to E. R. Hart for helpful suggestions on problems of stimulation and recording.

5. J. C. Lilly *et al.*, *Science* 121, 468 (1955). The pulse-pair generator was manufactured by the Grass Instrument Co.
6. All placements specified were verified histologically.
7. The amount of rest between sequences of brain-stimulation, both during and between experimental sessions, appears to be a critical factor. Rat F-49, for example, on continuous tegmental self-regulation, typically maintained the preferred level of 13 to 15 ma for about 30 minutes, and then increased the current to the top step, keeping it there by working only the "up" lever. This current-maximizing behavior was practically eliminated by introducing the 5-minute on-off procedure and spacing experimental sessions 2 to 3 days apart. Keeping in mind the discussion at the end of the present paper, and assuming with Olds (2) that positive and negative cell groups are reciprocally inhibitory, one may conclude that these effects may reflect temporary increases in the thresholds of negatively reinforcing structures that are brought about by the intensive self-stimulation of the positive site and which dissipate in time when rest is permitted.
8. J. Olds, *J. Comp. Physiol. Psychol.* 49, 281 (1956).
9. Continuous monitoring of the stimulating circuit by means of a cathode-ray oscilloscope and comparison resistances indicated that current increases were actually supplied to the brain and were not the result of artifacts such as polarization of the electrodes.
10. Findings related to these have been reported by W. W. Roberts, *J. Comp. Physiol. Psychol.* 51, 400 (1958) and by G. H. Bower and N. E. Miller, *ibid.* 51, 669 (1958).

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13 April 1959

Simple Method for Determining Potential Evapotranspiration from Temperature Data

Abstract. A value for the total amount of water that, theoretically, could be lost from soil and vegetation through evaporation and transpiration, if sufficient soil moisture were always available, may be obtained readily by multiplying a given time-period factor by the sum of time-unit means of positive centigrade temperatures divided by the number of time units in the period.

Potential evapotranspiration from areas of natural vegetation may be determined from temperature records alone by the use of the following formula:

$$\text{Potential evapotranspiration (in mm)} = \left[58.93\left(\frac{\text{Unit period of time}}{\text{No. of units of time in 1 yr}}\right)\right] \times \left[\text{Comparative plant growth mean temperature (°C)}\right]$$

Solved values for the first bracket for periods of time normally used for determining potential evapotranspiration are as follows: 1 year, 58.93; month of 31 days, 5.00; month of 30 days, 4.84; month of 28 days, 4.52; and 1 day, 0.16. For leap years, monthly values would be: 31 days, 4.99; 30 days, 4.83; and 29 days, 4.67.

For tropical and subtropical regions (except at high elevations) for all periods, and for other regions for periods when temperatures do not drop below 0°C, mean temperatures, as usually recorded or published, are represented by the value within the second bracket. For periods of time which include recorded temperatures below 0°C, the comparative plant growth mean temperature must be obtained in a different manner. The latter mean temperature was utilized as one factor for determining plant formations or life zones in a chart published in 1947 (*1*), and is considered to be the mean temperature of greatest significance to vegetation, and to be directly comparable in terms of plant life with the mean at any other point on our planet. The comparative plant growth mean temperature equals the sum of the average positive temperatures in degrees centigrade per unit of time, divided by the total number of these units of time in the period of the mean.

Thus, the mean annual temperature to be utilized in the formula equals the sum of the mean monthly temperatures above 0°C divided by 12. The monthly mean equals the sum of the daily means above 0°C, divided by the number of days in that particular month. The daily mean equals the sum of the hourly means above 0°C, divided by 24. At stations where mean daily temperatures are determined as one-half the sum of the maximum and minimum temperatures, such means are satisfactory except for days when the minima are below 0°C; on such days half of the maximum temperature, if it is positive, may be used as the daily mean.

Determination of potential evapotranspiration from temperature values alone, without need for data on precipitation or other climatic factors, is possible because of the two following considerations.

1) The potential evapotranspiration rate at a given temperature decreases proportionately along the gradient of increasing precipitation from arid to wet areas, so that the product of the evapotranspiration rate and the mean annual precipitation is the same all along the gradient. This is reflected in the regularity of the pattern of changes in physiognomy between the single climatic plant associations of each of the formations along the precipitation gradient.

2) Local variations in edaphic and atmospheric factors sufficient to cause an appreciable change in either evaporation or transpiration, or in both, are counterbalanced by the different physiognomies of the natural vegetation, developed in the past through evolutionary processes, which bring the actual evapotranspiration into equilibrium with the potential evapotranspiration rate and the moisture available. These variations are reflected in the diversity of aspect and lack of regularity of the pattern of changes of the physiognomies of the (usually several) edaphic, atmospheric, and hydric associations of the same plant formations along the moisture gradient.

L. R. HOLDRIDGE

Technical Cooperation Program, Organization of American States, San José, Costa Rica

Reference

1. L. R. Holdridge, *Science* 105, 367 (1947).

25 March 1959

Decrease in Threshold without Depolarization in Cyanide-Treated Muscle

Abstract. When smooth muscle of *Mytilus* is treated with relatively weak solutions of sodium cyanide, a transitory hyperpolarization or no change in polarization precedes final depolarization. Thresholds for thermal, chemical, and electrical stimulation are all decreased during this period. Strength-duration curves indicate a reversible decrease in threshold of about 50 percent during this period.

As an outgrowth of investigations into the nature of the mechanism of the cooling stimulus in smooth muscle of *Mytilus* (*1*), we decided to examine the relationship between inhibition of respiration by metabolic poisons and the effects of these

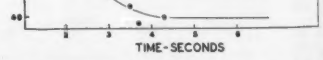

Fig. 1. Strength-duration curves for (A) normal *Mytilus* muscle in sea water; (B) the same muscle after treatment for 1 hour in 5m*M* NaCN; and (C) the same muscle subsequently allowed to recover for 1.5 hours in sea water (intensity of threshold square wave pulses in microamperes versus duration in seconds). The rheobase is decreased after treatment with cyanide, and this effect is partially reversible in sea water. The resting potential, which usually returned to the normal value after recovery in sea water, did not do so in this particular muscle, perhaps because of relatively long treatment with cyanide.

poisons on the threshold to cooling (*2*).

Resting potentials, recorded between the depolarized and experimental end of the muscle, were amplified and led to one channel of a dual-channel rectilinear galvanometric recorder, as in previous studies. Changes in tension were detected by a sensitive isometric transducer (*3*) in a bridge circuit, amplified, and led to the second channel of the recorder. The same electrodes were used for stimulating and for recording potentials.

We realized, of course, that prolonged treatment with sufficiently high concentrations of metabolic inhibitor would depress the resting potential irreversibly. Also, since it had been found in studies of this muscle that any agent which resulted in subthreshold depression of the resting potential enhanced the effect of cooling, it was obvious that one should expect that an interference with respiration would *ipso facto* decrease the threshold to cooling stimulation or to a chemical stimulus such as the application of potassium ion. This was indeed found to be the case.

However, we noticed that, in treatment with sodium cyanide, the eventual depression of the resting potential was preceded by a period in which either no change in potential occurred or an initial marked but transitory *rise in* resting potential developed if 1 or 2.5 or even 5 m*M* solutions of NaCN in sea water were used. This raised the question of the significance of the change to muscle excitability.

In 1952 Ling (*4*) carried out a similar study. He investigated the effects of metabolic inhibitors upon the resting potentials of frog muscle and found that 5 m*M* NaCN, which did not in itself produce a significant fall in resting potential in frog muscle, greatly hastened the fall in resting potential caused by 5 m*M* iodoacetate if the cyanide and the iodoacetate were simultaneously applied. Following this lead in our studies of invertebrate muscle, we found that during the initial treatment with cyanide, the threshold amount of cooling necessary for contraction of *Mytilus* muscle was also decreased. It was also possible to potentiate the stimulating effects of the potassium ion by means of this procedure, which does not, in the concentrations used, decrease the membrane potential but, rather, usually enhances it.

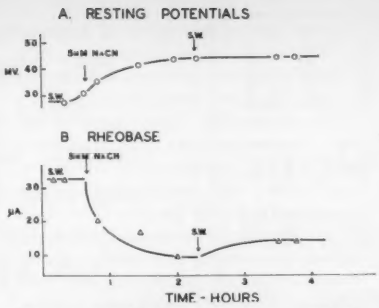

Fig. 2. Resting potentials, in millivolts (A), and rheobase, in microamperes (B), versus time, in hours, for *Mytilus* muscle treated with 5m*M* NaCN and allowed to recover in sea water. In this muscle, the time course of development of hyperpolarization mirrors the decrease in rheobase.

The phenomenon of a decrease in threshold unaccompanied by depolarization was felt to be of sufficient interest to merit further study. Consequently, in order to investigate changes in excitability quantitatively, the classical strength-duration curves were determined, first on normal muscle in sea water and then on the muscle during treatment with NaCN. Resting potential values were recorded concurrently.

It is clear that on treatment with NaCN, a decrease in threshold (*5*), unaccompanied by membrane depolarization, occurs, and that this effect is partially or completely reversible (depending upon the duration of treatment with cyanide) when the muscle is returned to sea water (Fig. 1). In Fig. 2, determinations of the rheobase and subsequently recorded resting potentials in another muscle are plotted against time. A correlation between degree of hyperpolarization and decrease in threshold evident in this experiment was encountered in many cases.

Hodgkin and Keynes (*6*) found that cyanide reduces the rate of sodium efflux in cephalopod axons, but this is not the case in frog muscle (*7*).

In *Mytilus* muscle, the situation is doubtless a complex one and may well involve changes in the concentrations of ions inside and outside the fibers, and changes in charge as well as changes in membrane permeability. One might attempt to explain the hyperpolarization in terms of movements of ions or water.

It is true that depolarization is normally the first step in excitation. However, the use of cyanide or some other agent may possibly affect a link in the chain of events further along than depolarization, and thus activate the contractile process (*8*).

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2. This work was supported in part by grant B-799(C3) made to one of us (R.G.) by the National Institutes of Health.
3. S. M. Ross, *Rev. Sci. Instr.* **29**, 319 (1958).
4. G. N. Ling, "The role of phosphate in the maintenance of the resting potential and selective ionic accumulation in frog muscle cells," in *Phosphorus Metabolism* (Johns Hopkins Press, Baltimore, 1952).
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6. A. L. Hodgkin and R. D. Keynes, *J. Physiol. (London)* **128**, 28 (1955).
7. R. D. Keynes and G. W. Maisel, *Proc. Roy. Soc. (London)* **142B**, 383 (1954).
8. For a discussion of this point see A. Sandow, *Am. J. Phys. Med.* **34**, 145 (1955), and R. Niedergerke, *J. Physiol. (London)* **134**, 584 (1956).

24 August 1959

Meetings

Nuclear Fuels

The U.S. Atomic Energy Commission, in cooperation with AEC contractors, will sponsor a 2-day symposium for management and technical personnel on the reprocessing of nuclear fuels, in Richland, Washington, 20–21 October. The symposium is designed to renew the technology currently available for reprocessing spent fuels from research, test, and power reactors. The Atomic Energy Commission plans to reprocess in existing AEC facilities spent fuels from civilian reactors until such service is available from private industry.

The symposium will be open to private reactor operators, fuel fabricators, AEC and AEC-contractor personnel, foreign visitors, and certain other management and technical personnel. Management and technical personnel wishing to attend the meeting may obtain details from the program coordinator, Mr. J. T. Christy, Hanford Operations Office, U.S. Atomic Energy Commission, Richland, Wash.

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International Conservation

The seventh general assembly and technical sessions of the International Union for Conservation of Nature and Natural Resources will be held in Warsaw, Poland, 14–24 June 1960, with field trips both during and after the assembly. The Polish Government promises excellent arrangements. The program will include an introductory session on "The Impact of Man and Modern Technology on Nature and Natural Resources." Pesticide problems will be considered in sessions under the title "Ecological Effects of the Biological and Chemical Control of Undesirable Plants and Animals," and there will also be papers on "Management of Wild Grazing Animals in Temperate Zones and Its Relation to Land Use."

Those wishing to receive detailed announcements of the Warsaw meeting may write to the Secretary-General, IUCN, 31 rue Vautier, Brussels, Belgium. Correspondence may also be directed to either of the two U.S. members of the executive board of the union —Harold J. Coolidge, National Research Council, Washington, D.C., and Edward H. Graham, Soil Conservation Service, Washington, D.C.

Animal Care Panel

The 10th annual meeting of the Animal Care Panel will be held at the Sheraton Park Hotel, Washington, D.C., 29–31 October. Some 500 research workers interested in the care of laboratory animals are expected to attend. Programs and information may be obtained from Mr. Burton Hill, Animal Care Panel, NAS–NRC, 2101 Constitution Ave, NW, Washington 25, D.C., who is in charge of advanced registration. The price of the hotel rooms will be $9 single and $15 double.

Many movies about laboratory animal care have been filmed in the last few years. A number of these movies have been selected by the Program Committee and they will be shown continuously each day in the area adjoining the exhibit hall. The formal program will consist of six sessions of four papers each. There will be about 70 commercial exhibits and a large number of scientific exhibits.

Logic, Methodology, and Philosophy

An International Congress for Logic, Methodology and Philosophy of Science will be held at Stanford University from 24 August to 2 September 1960 under the auspices of the International Union for History and Philosophy of Science.

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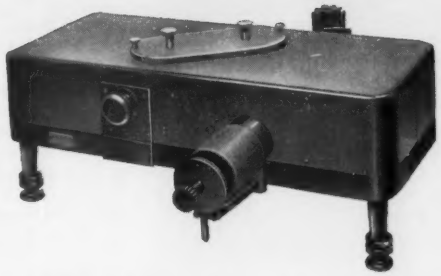

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Occupation.....

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Is car principally kept and used on a farm or ranch?.....

Yr.	Make	Model (Dlx., etc.)	Cyl.	Body Style	Purchase Date Mo. Yr.	☐ New ☐ Used

1. (a) Days per week car driven to work?..... One way distance is.....miles.
(b) Is car used in any occupation or business? (Excluding to and from work) ☐ Yes ☐ No

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The congress will be organized into the following sections: mathematical logic; foundations of mathematical theories; philosophy of logic and mathematics; general problems of methodology and philosophy of science; foundations of probability and induction; methodology and philosophy of physical sciences; methodology and philosophy of biological and psychological sciences; methodology and philosophy of social sciences; methodology and philosophy of linguistics; methodology and philosophy of historical sciences; and history of logic, methodology, and philosophy of science.

The proceedings will consist of a number of invited addresses, in addition to brief contributed papers. The closing date for submission of abstracts of contributed papers is 1 March 1960. Information may be obtained by writing to Prof. Patrick Suppes, Serra House, Stanford University, Stanford, Calif.

Forthcoming Events

October

1–4. American Soc. of Industrial Designers, Asheville, N.C. (Mrs. R. R. Larisch, ASID, 15 E. 48 St., New York 17.)

4–7. American Inst. of Mining, Metallurgical and Petroleum Engineers, fall, Dallas, Tex. (E. O. Kirkendall, AIMMPE, 29 W. 39 St., New York 18.)

4–9. Society of Motion Picture and Television Engineers, semi-annual conv., New York, N.Y. (C. S. Stodter, SMPTE, 55 W. 42 St., New York, 36.)

5–7. Aeronautical Communications, 5th symp., Utica, N.Y. (L. G. Cumming, Inst. of Radio Engineers, 1 E. 79 St., New York 21.)

5–7. Chemical Engineers, annual, Essen, Germany. (Dr. Miessner, VDI-Fachgruppe, Verfahrenstechnik, Rheingauallee 25, Frankfurt-am-Main.)

5–7. National Assoc. of Corrosion Engineers, Northeast regional, Baltimore, Md. (T. J. Hull, NACE, 1061 M & M Bldg., Houston, Tex.)

5–8. American Acad. of Pediatrics, Chicago, Ill. (E. H. Christopherson, 1801 Hinman Ave., Evanston, Ill.)

5–9. American Soc. of Anesthesiologists, Bal Harbour, Fla. (J. W. Andes, 188 W. Randolph St., Room 1101, Chicago, Ill.)

5–9. Audio Engineering Soc., 11th annual, New York, N.Y. (AES, P.O. Box 12, Old Chelsea Station, New York 11.)

5–10. Society of Automotive Engineers, aeronautical meeting and aircraft manufacturing forum, Los Angeles, Calif. (R. W. Crory, Meetings Operation Dept., SAE, 485 Lexington Ave., New York 17.)

5–16. Institute of the Aeronautical Sciences, biennial Anglo-American conf., New York, N.Y. (R. R. Dexter, IAS, 2 E. 64 St., New York 21.)

6. American Assoc. of Poison Control Centers, 2nd annual, Chicago, Ill. (A. S. Blank, AAPCC, Connecticut State Dept. of Health, Hartford 15.)

6–8. Aeronautical/Astronautical Problems of High Speed Flight, Stanford, Calif. (E. Haynes, Deputy Director, Aero Sciences Directorate, Air Force Office of Scientific Research, Washington 25.)

6–9. High Temperature Technology, intern. symp., Asilomar, Calif. (Public Relations Office, Stanford Research Inst., Menlo Park, Calif.)

7–8. Advanced Propulsion, 2nd symp. (classified), Boston, Mass. (Lt. Col. P. Atkinson, Propulsion Div., Air Force Office of Scientific Research, Washington 25.)

7–9. Vacuum Technology, symp., Philadelphia, Pa. (American Vacuum Soc., Box 1282, Boston, Mass.)

7–11. International Conv. on Nutrition and Vital Substances, 5th, Konstanz-Zurich, Switzerland. (Secretary General, Benmeroderstrasse 61, Hannover-Kirchrode, Germany.)

8–10. American Assoc. of Textile Chemists and Colorists, natl. conv., Washington, D.C. (G. P. Paine, AATCC, P.O. Box 28, Lowell, Mass.)

8–10. American Ceramic Soc., Bedford, Pa. (F. P. Reid, ACS, 4055 N. High St., Columbus 14, Ohio.)

8–10. American Soc. of Tool Engineers, semi-annual, St. Louis, Mo. (H. E. Conrad, ASTE, 10700 Puritan Ave., Detroit 38, Mich.)

8–10. Biology of Pyelonephritis, intern. symp., Detroit, Mich. (E. L. Quinn, Henry Ford Hospital, W. Grand Blvd. at Hamilton, Detroit 2.)

8–10. Optical Soc. of America, annual, Ottawa, Canada. (S. S. Ballard, Dept. of Physics, Univ. of Florida, Gainesville.)

9–13. American Soc. of Civil Engineers, Los Angeles, Calif. (E. S. Kirkpatrick, ASCE, 33 W. 39 St., New York 18.)

11–16. American Acad. of Ophthalmology and Otolaryngology, Chicago, Ill. (W. L. Benedict, 15 Second St., SW, Rochester, Minn.)

11–16. American Inst. of Electrical Engineers, fall general, Chicago, Ill. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

11–16. American Soc. for Testing Materials, Pacific area natl., San Francisco, Calif. (R. J. Painter, ASTM, 1916 Race St., Philadelphia 3, Pa.)

12–14. Clay Conf., 8th natl., Norman, Okla. (C. G. Dodd, Eighth Natl. Clay Conf., University of Oklahoma, Norman.)

12–14. Electronics Conf., 15th annual natl., Chicago, Ill. (NEC, 228 N. La Salle St., Chicago 1, Ill.)

12–16. Macromolecules, intern, symp. (IUPAP), Wiesbaden, Germany. (W. Mauss, Intern. Symp. on Macromolecules, c/o Kalle & Co., Rheingaustrasse 25, Wiesbaden-Biebrich, Germany.)

12–19. Venereal Diseases, intern. cong. (by invitation), London, England. (G. E. W. Wolstenholme, Ciba Foundation, 41 Portland Pl., London, W.1, England.)

13–17. International Union against the Venereal Diseases and the Treponematoses, London, England. (Institut Alfred Fournier, 25, Boulevard Saint-Jacques, Paris 14e, France.)

14–16. Parenteral Drug Assoc., annual conv., New York, N.Y. (H. E. Boyden, Parenteral Drug Assoc., 130 E. 59 St., New York 22.)

(See issue of 21 August for comprehensive list)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable, and it reflects the claims of the manufacturer or other source. Neither Science *nor the writer assumes responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 582.*

■ TEMPERATURE CONTROLLER for high-power applications controls 140 kva if water-cooled ignitrons are used or 50 kva if air-cooled types are used. The regulator includes an electronic controller and an ignitron firing circuit. By varying the firing angle of the ignitrons, the controller proportionally regulates the load power. (Research Inc., Dept. 18)

■ VOLTAGE-TO-FREQUENCY CONVERTER accepts d-c input voltage from 0 to 1000 v in four ranges and provides corresponding frequency output from 0 to 10,000 cy/sec. Input impedance is 1 megohm shunted by 200 pf. Accuracy of ± 0.1 percent of full scale is claimed. Signals of either polarity may be measured. A mercury cell within the instrument permits calibration. (Dymec Inc., Dept. 21)

■ WELDER can be used to put taps onto single turns of potentiometer windings made of 0.0005-to-0.008-in. wire. A thin ribbon material is used to obtain connections with low terminal resistance. A built-in ohmmeter and an electronic metering circuit produce an audible signal to indicate the correct turn to which the weld is to be made. (Ewald Instruments, Dept. 23)

■ SIGNAL GENERATOR covers the frequency range 125 kcy to 175 Mcy/sec in calibrated bands, both modulated and unmodulated. Crystal-controlled frequencies are provided on harmonics up to 250 Mcy/sec. Output is metered from 0.1 to 10^6 μv without external attenuation. (Hickok Electrical Instrument Co., Dept. 24)

■ BALL REBOUND TESTER tests resilience of foamed plastic by dropping a steel ball ⅝ in. in diameter onto the sample and measuring the rebound. The steel ball is released in a clear plastic vertical tube by an electromagnet. Circles scribed on the tube aid in estimating rebound height. (Custom Scientific Instruments, Dept. 25)

■ AMINO-ACID ANALYZER performs analysis of over 20 amino acids in less than 24 hr. Results are said to be consistent within ± 2 to 3 percent. The instrument separates the amino acids, carries out the Ninhydrin reaction on the effluent, and records the optical density photometrically. Temperature is controlled within ± 0.2°C. Output can be read to

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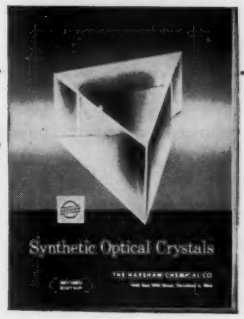

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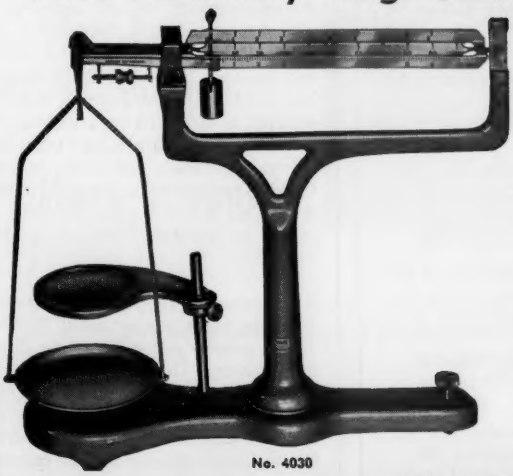

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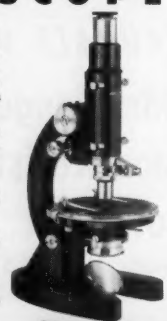

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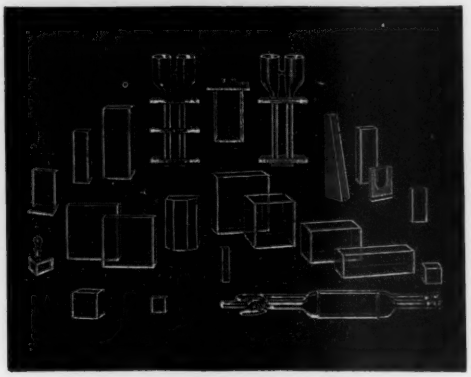

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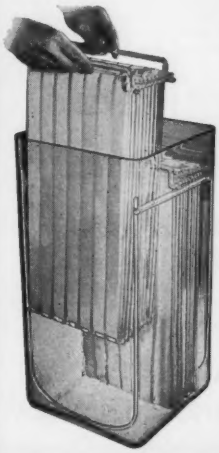

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In the below list, check page number of advertiser from whom you would like more information. If more than one item appears in ad, letters **A, B, C** are used to indicate particular items available in order of appearance in advertisement. Where more than one ad appears on page, **U** indicates upper ad, **L** lower ad, **I** inside ad, **M** middle ad, and **O** outside ad. The covers are designated by **IFC** (inside front cover), **IBC** (inside back cover), and **OBC** (outside back cover). Advertisements in Personnel Placement are not keyed; only fractional pages (one-sixth or larger) in the Market Place are keyed. A multiplicity of items is indicated by *. Readers are requested to specify on this coupon the particular item in which they are interested; otherwise, the request cannot be processed.

☐ IFC	☐ 523*	☐ 524	☐ 525	☐ 526
☐ 528	☐ 529	☐ 531	☐ 534	☐ 574
☐ 575, UI	☐ 575, UO	☐ 575, L	☐ 577, U-A	☐ 577, U-B
☐ 577, L	☐ 578, U	☐ 578, LO	☐ 579, UI	☐ 579, UO
☐ 579, L	☐ 580, UO	☐ OBC		

GET YOUR ADVANCE COPY

of the General Program of the AAAS Chicago Meeting

by first class mail – early in December

The General Program of the 126th Meeting of the AAAS in Chicago, 26–31 Dec., 1959, will be available to you within the first week in December—whether you can attend the Meeting or not.

Effective this year, the former General Program-Directory, which had become an unwieldy book of more than 400 pages, has been separated into **two** publications, namely:

a) The Directory of AAAS Officers and Activities, 96 pp., already published; and

b) The General Program of the Annual Meeting, c. 200 pp., which will appear early in December.

Both of these, sold at cost, may be purchased separately—in advance (see coupon below), or at the meeting. Some of their *respective* contents are:

The General Program

1. The two-session general symposium, "Moving Frontiers of Science IV," arranged by the Committee on AAAS Meetings.
2. Programs of the 18 AAAS sections (symposia and contributed papers).
3. Programs of the more than 70 participating societies.
4. Sessions of the Conference on Scientific Communication, Conference on Scientific Manpower, and the Academy Conference.
5. The Special Sessions: AAAS Address and Reception, National Geographic Society, Phi Beta Kappa, Sigma Xi, RESA, Tau Beta Pi Association.
6. Details of the Morrison Hotel—center of the Meeting—and of the other session sites.
7. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
8. Exhibitors in the 1959 Annual Exposition of Science and Industry and descriptions of their exhibits.

The Directory

1. AAAS officers, staff, committees for 1959.
2. Section committees and other AAAS Council members.
3. The 285 affiliated organizations.
4. Historical sketch and organization of the Association.
5. Complete roll of AAAS presidents and their fields.
6. Publications of the Association, including all symposium volumes.
7. AAAS Awards—including all past winners.
8. Future Meetings of the AAAS through 1963.
9. New and current activities of the AAAS.
10. Constitution and Bylaws.

Advance Registration

Advance registration has these decided advantages: 1) You avoid delay at the Registration Center upon arrival; 2) You receive the General Program in ample time to decide, unhurriedly, which events and sessions you particularly wish to attend; 3) Your name is posted in the Visible Directory as the Meeting opens.

The following coupon may be used both by advance registrants and by those who wish only the advance copy of the General Program; the Directory may also be ordered.

—THIS IS YOUR COUPON FOR AN ADVANCE COPY OF THE GENERAL PROGRAM— (AND FOR THE DIRECTORY, IF ALSO DESIRED)

1a. ☐ Enclosed is $3.00 for my advance Registration Fee which brings me the General Program, Convention Badge, and all privileges of the Meeting.

1b. ☐ Enclosed is $2.00 for only the General Program. (It is understood that, if I should attend the Meeting later, the Badge—necessary for the privileges of the Meeting—will be secured for $1.00 more.)

(Check 1a or 1b)

1c. ☐ Enclosed is $1.00 for the Directory of AAAS Officers and Activities to be sent now.

Total amount enclosed $.....

2. FULL NAME (Dr., Miss, etc.) .....
(Please print or typewrite) (Last) (First) (Initial)

3. ACADEMIC, PROFESSIONAL, OR BUSINESS CONNECTION .....

4. OFFICE OR HOME ADDRESS .....
(For receipt of General Program and/or Directory)

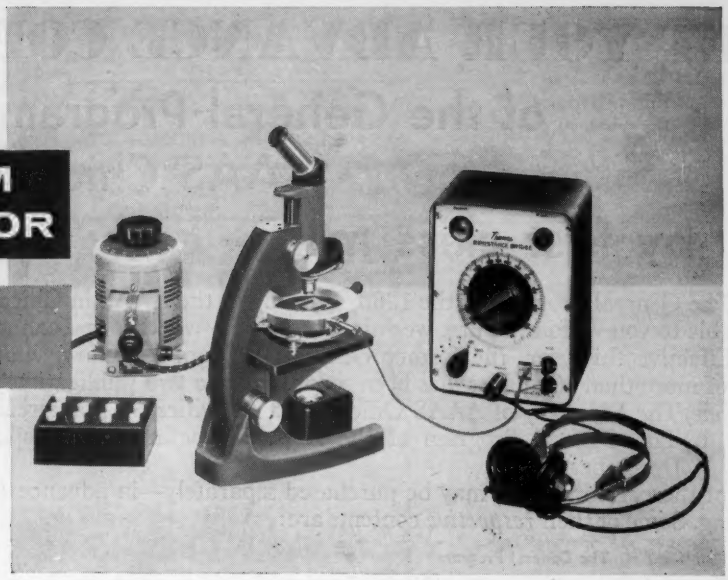
5. FIELD OF INTEREST .....

6. CONVENTION ADDRESS .....
(May be added later, after arrival)

Please mail this Coupon and your check or money order for the total amount to the
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
1515 Massachusetts Avenue, NW, Washington 5, D.C.

Thomas

AUDIOHM THERMISTOR *for* KOFLER HOT STAGE



. . . for determining melting points by use of a thermistor in place of mercury-in-glass thermometers

Advantages:

- **Can be used with any Thomas-Kofler Hot Stage**
- **Audible signal permits *uninterrupted* observation**
- **Single sensor for entire temperature range**
- **Faster response**
- **Simple graphic reader converts resistance values to temperature readings**
- **Bridge Alarm permits unattended heating and cooling of Stage**

3963-A7.

AUDIOHM THERMISTOR KOFLER HOT STAGE ASSEMBLY, Thomas. For determination of micro melting points and other fusion phenomena temperatures *without removing the eye from the microscope.*

Other advantages of the thermistor method are faster response, obtained by locating a smaller sensor closer to the field of observation than is possible with a thermometer, and the elimination of stage-calibrated thermometers.

Uninterrupted observation of fusion through all phases is made possible by measuring temperature as a function of thermistor resistance, which can be determined at any given instant by manually nulling the audible bridge signal. Dial reading remains unchanged and can be recorded subsequently. The Bridge Alarm, offered as an optional accessory, signals approach to a preset balance point, permitting the operator to leave the stage unattended while it heats or cools.

The assembly shown above consists of Thomas-Kofler Hot Stage—described on pp. 877 to 880, incl., of our catalog—with the following Audiohm Thermistor accessories in place of the usual thermometers:

Thermistor Hot Stage Attachment. A chromium plated, circular brass block, with 1 mm bead type thermistor. Fits directly on any Thomas-Kofler Hot Stage in place of detachable rim.

Audiohm Resistance Bridge. Range 0.2 to 2,500,000 ohms, 1000-cycle output; with phone jack for earphones, and octal socket in rear to take Bridge Alarm.

Earphones. For attachment to Resistance Bridge to detect null point of audible signal.

Thermistor Temperature Computer. A circular slide rule on 16-inch square plastic base plate. For converting resistance values directly to temperature readings in the range 20° to 350° C.

6887-C2. Audiohm Thermistor Hot Stage Assembly, Thomas-Kofler, complete as illustrated, consisting of Hot Stage with transformer, Thermistor Attachment for the stage, Audiohm Resistance Bridge, Earphones, and Thermistor Temperature Computer; without Microscope or Bridge Alarm. For 115 volts, 50 or 60 cyc. a.c. **422.95**

6887-B. Thermistor Hot Stage Attachment, only, for use on Thomas-Kofler Hot Stage . . **50.25**

3963-A5. Resistance Bridge, Thomas Audiohm **228.00**

3963-A7. Resistance Bridge Alarm, Buzzer Type, Thomas **38.50**

3930-M2. Earphones, only **12.00**

6884-F. Thermistor Temperature Computer, Thomas **20.00**

More detailed information sent upon request.

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